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Distribution and Abundance of Hoary Marmots in North Cascades National Park Complex, Washington, 2007-2008

Natural Resource Technical Report NPS/NOCA/NRTR—2012/593

ON THE COVER
Hoary Marmot (*Marmota caligata*)
Photograph courtesy of Roger Christophersen, North Cascades National Park Complex

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Contents

Contents (continued)

Figures

Page

Figures (continued)

Page

Tables

Page

Appendices

Page

Executive Summary

A two-year systematic baseline survey of hoary marmot (*Marmota caligata*) distribution and abundance was conducted in North Cascades National Park Complex (NOCA) from late June to early September 2007 and 2008. Surveys sites were located in meadow habitat above 1,219 m (4,000 ft) and were accessible by trail. Thirty-one sites were randomly selected from the sampling universe and surveyed using a point count sampling system spaced every 400 m along trail transects. The number of point count stations ranged from 2 to 9 (mean = 4) points per survey site. Surveyors detected 242 marmots at 19 of 31 (61%) sites with abundance ranging from 0 to 25 individuals per site (mean = 7.8; standard error [SE] = 1.5). Marmots occupied areas ranging in elevation from 1,158–2,115 m (mean = 1,789 m; SE = 28.7) largely on south-facing slopes (54.5%).

Of the 31 sites surveyed, 123 individual point count stations were established and sampled, of which 58 (47%) yielded marmot detections. Generally, all marmots detected at each point count station were collectively called a colony. However, on three occasions surveyors distinguished two colonies from a single point count station. Hence, 61 separate colonies were identified consisting of a minimum of 242 marmots. Age classifications consisted of 145 (59%) adults, 33 (14%) yearlings, 31 (13%) juveniles, and 33 (14%) animals of unknown age. Young of the year were confirmed at 13 of 31 (42%) survey sites and at 20 of 61 (33%) colonies.

In 2007, all survey sites (21) were visited on one occasion only. In 2008, eight new sites were surveyed, four of which were surveyed twice to examine intra-year variability in occupancy and abundance. In addition, surveyors repeated visits to four sites reported as unoccupied in 2007 and visited four sites that were surveyed once in 2007 and again surveyed twice in 2008 to examine intra and inter-year variability in occupancy and count numbers. Eleven of 12 (92%) repeat visits showed the same results, whereas occupancy was confirmed in each of the two surveys, while one site resulted in occupancy only on the second visit. However, there were slight increases in total number of marmots counted with increasing date at 50% of sites. One of the four sites not occupied by marmots in 2007 was found to be occupied during 2008 surveys, establishing a newly discovered colony. Since marmots exist in a metapopulation dynamic, it is not certain whether this site was unoccupied in 2007 and subsequently recolonized in 2008, or if the site was actually occupied in 2007, but presence went undetected.

Statistical modeling and information theoretic techniques were used to examine variables affecting marmot abundance counts. The area of each survey site and the site location relative to the Cascade Mountain and Picket Range crests were significant in the top model. Marmot abundance was positively correlated with survey site area and negatively correlated with sites located west of both crests. Additionally, abundance was positively correlated with an interaction between elevation and west-side sites, suggesting that sites west of the crest supported more marmots at higher elevations.

Counts may underestimate actual marmot abundance, since in all likelihood not all animals were visible during surveys and some sites were surveyed prior to expected dates of juvenile emergence. However, despite this underlying assumption, survey efforts were successful in describing general characteristics of marmot habitat, identifying presence and determining minimum counts of abundance and density at survey sites. This in turn has offered invaluable

insight regarding current distribution and abundance of marmots in NOCA. Recommendations are included in this report for future monitoring of marmots using presence-absence methodology.

Acknowledgments

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Introduction

The hoary marmot (*Marmota caligata*) is a widespread mammal occupying alpine habitats of western North America. It is found throughout the Rocky and Cascade Mountain ranges, from central Alaska and the Yukon Territory, south as far as northwest Montana, Idaho, and Washington (Banfield 1977). The environment throughout their range is characterized by long cold winters with deep snow and brief cool summers. Environmental constraints force these animals to compress their annual feeding, growth, and breeding activities into 4-5 months while spending the remainder of the year in hibernation (Barash 1974). The hoary marmot is closely related to, and shares social and life-history traits with, the Vancouver Island marmot (*M. vancouverensis*; Bryant 1996) and Olympic marmot (*M. Olympus*; Barash 1973). All three species exhibit low reproductive rates, a relatively long life span, and a highly organized social structure (Barash 1974, Holmes 1979). Like all marmot species, the hoary marmot relies on burrows for shelter from predators and weather. These burrows may be used continuously for many years and may represent a limiting resource (Armitage 2003).

Climate change threatens to modify the geographic distribution and structure of high-mountain ecosystems (Burns et al. 2003; Guralnick 2007). Marmots (Inouye et al. 2000), along with pika (Beever et al. 2003), have been singled out as alpine mammals warranting concern; and marmots are one of a handful of species that may be suitable for monitoring changes in alpine ecosystems (Martin 2001, MacNally and Fleishman 2004). Commercially, they have little value in North America and therefore experience little direct human-related mortality in comparison with other alpine animals (i.e., mountain goats, sheep, ptarmigan). Likewise, their remote habitat is rarely directly impacted by development or logging. As a result, changes in marmot populations are more likely to reflect changes in climate, habitat quality, or predator-prey dynamics. Furthermore, hoary marmots are widespread, confined to easily identified habitat, and easily observed, characteristics that are desirable in an indicator species. They are expected to exhibit a reasonably strong response to climate change: marmot survival and reproduction is measurably influenced by snowpack depth (Arnold 1990, Barash 1989) and the timing of spring melt (Van Vuren and Armitage 1991, Schwartz and Armitage 2005). Inouye et al. (2000) also postulated that a climate change-induced disconnect between emergence timing and food availability could affect these life history traits.

There is little information about dispersal or temporal occupancy patterns for hoary marmots, but evidence from other marmot species suggest that larger habitat patches rarely become vacant. Females of Olympic and the somewhat more distantly related yellow-bellied marmot (*M. flaviventris*) rarely disperse >1km, severely limiting the opportunity for recolonization of remote patches (Van Vuren 1990, Griffin et al. in press). Second, in a stable population of yellow-bellied marmots, larger colonies were continuously occupied for >40 years and served as a critical source of dispersing individuals for recolonizing smaller patches that occasionally became vacant (Ozjul et al. 2006). Available data is consistent with a similar pattern in Olympic marmots during a 30-year period of apparent stability (Griffin et al. 2008). A heavy reliance on the continuous occupancy of a few large habitat patches and the associated burrow systems may increase marmots' sensitivity to climate change or other ecosystem-level changes. If tree encroachment, declining forage quality, or increased predation results in the extinction of a patch that historically served as a source of colonists, the result may be regional extinction (Ozgul et al. 2006).

Marmot populations in the Pacific Northwest have been declining in recent decades. The Vancouver Island marmot declined in the 1980's and 1990's and is now critically endangered (Shank 1999). After dropping to below 30 animals, the wild population is now sustained by ongoing reintroductions of captive bred individuals (Kruckenhauser et al. 2009). The declines appear to be a result of increased predation, including wolves, cougar, and golden eagles (Bryant and Page 2005); changes in predator distribution, abundance, and behavior likely resulted from extensive clearcutting and road-building at high-elevation on Vancouver Island.

The Olympic marmot, endemic to Olympic National Park (OLYM), has also declined in recent years (Griffin et al. 2008). Like the Vancouver Island marmot, the Olympic marmot is confined to an isolated land mass and probably numbered no more than 2,000 individuals at any point in the last century (Sheffer 1995, Griffin et al. 2008). Both occupancy rates and abundance at colonies in the northeast section of OLYM have declined in recent decades, and a high ratio of abandoned to occupied habitat suggests that the declines are a park-wide phenomenon (Griffin et al. 2008). Multiple lines of evidence suggest that predation by coyotes on adult females is the primary cause of declines; survival of radio-tagged adult females is extremely low (Griffin et al. 2008), predation by coyotes is the most common cause of mortality (Griffin 2007), and marmots constitute up to 20% of coyote summer diet in several parts of the park (Witczuk 2007). Historically, coyotes were not known to occur on the Olympic Peninsula (Sheffer 1995). However, the extirpation of wolves and changes in the landscape associated with intensive logging may have facilitated the range expansion and subsequent success of the coyote. Generally lower than normal snowpack depth in the last years may have made the high country more accessible to coyotes; predation on adult female marmots is considerably higher in years with below average snowpack (S.C. Griffin, unpublished data).

Both the Olympic and the Vancouver Island marmot have reproductive rates on the lower end of the range typical for marmots (Bryant 2005, S. C. Griffin, personal communication). Whether these rates are "normal" for these species, and if not, the relative effects of climate change and inbreeding remains to be determined (Kruckenhauser et al. 2009). However, the many parallels between the Olympic and Vancouver Island marmots suggest the presence of regional influences that could affect hoary marmot populations in the North Cascade Mountains.

Little is known about the ecology or distribution of hoary marmots in North Cascades National Park Complex (NOCA). The only existing data consist of approximately 32 anecdotal occurrence records in the park's wildlife database. Alpine habitats in the park have been largely unaffected by management activities such as logging or road building, thus offering a unique opportunity for monitoring the direct or indirect effects of potential large scale impacts. Hoary marmots in NOCA may or may not be affected by land management activities and associated changes in predator communities in the same manner as Olympic and Vancouver Island marmots, however the effects of climate change will be inescapable.

Evaluating the impact that climate change or other types of disturbance will have on hoary marmot populations in NOCA requires a long-term monitoring program. The objective of this project was to conduct a baseline inventory to describe the current distribution and abundance of marmot colonies in NOCA. Data collected during the inventory provide a foundation for an ongoing monitoring program that can be used to assess future changes in habitat conditions and population trends over time.

To address the need for information about the status of hoary marmots in NOCA, we conducted a systematic survey of suitable marmot habitat in the park complex. This report summarizes hoary marmot surveys conducted in NOCA during summers 2007 and 2008. The objectives of this survey are as follows:

1.) Describe the current patterns of distribution and abundance.
2.) Describe general habitat characteristics where marmots were located.
3.) Determine density estimates for areas surveyed.

Study Area

The park complex encompasses 276,815 ha located in northwestern Washington State and is comprised of three management units: North Cascades National Park, Ross Lake National Recreation Area and the Lake Chelan National Recreation Area (Figure 1). Approximately 93% of this area is managed as designated wilderness. Surrounding the park on the west, south and east are 1.9 million ha of national forest lands, of which 763,890 ha are designated wilderness most of which are contiguous to the park. NOCA's northern boundary is the international border with the Canadian province of British Columbia. Adjacent to NOCA's boundary in British Columbia the land is designated as managed provincial forest, recreation area, and protected park lands.

Westerly trending weather patterns combined with the high topographic relief have created distinct east-west and mid-divide precipitation patterns. Precipitation gradients occur along either side of an orographic divide defined by the Picket Range, in the northern portion of the park, and the Pacific Crest Divide to the south (Sumioka et al. 1998). On the west of this divide precipitation averages between 203 and 897 cm annually. This region represents a seasonally wet maritime climate where summers are relatively dry and typically cool with the majority of precipitation falling during the mild wet winters. To the east precipitation drops to an average of 76 cm in the lower elevations of the Stehekin Valley. This region is much more influenced by continental air masses creating conditions that consist of cold snowy winters and warm dry summers.

The range of elevation, moisture and temperature differences create a variety of vegetation cover types throughout the park. Surveys for this project were restricted to alpine/subalpine communities above 1,219 m (4,000 ft), with one exception at a survey site that included a meadow at 1,158 m (3,799 ft). Dominant herbaceous vegetation for these communities includes the broadly described lush herb and heather cover types (Agee and Kertis 1986). These cover types are found in dry and moist conditions, both east and west of the crest. The lush herb type occupies more area (9.3%) than any other non-forest vegetation cover type in the park complex (Agee and Kertis 1986).

Other less dominant cover types include the high shrub type, often found in moist avalanche chutes, and a mixture of open canopy subalpine fir (*Abies lasiocarpa*), mountain hemlock (*Tsuga mertensiana*) and whitebark pine (*Pinus albicaulis*)/subalpine larch (*Larix lyallii*) as forest types (Agee and Kertis 1986). Most of the whitebark pine/subalpine fir is found in drier conditions east of the crest, while the mountain hemlock cover type is generally found on the moist west side of the park.

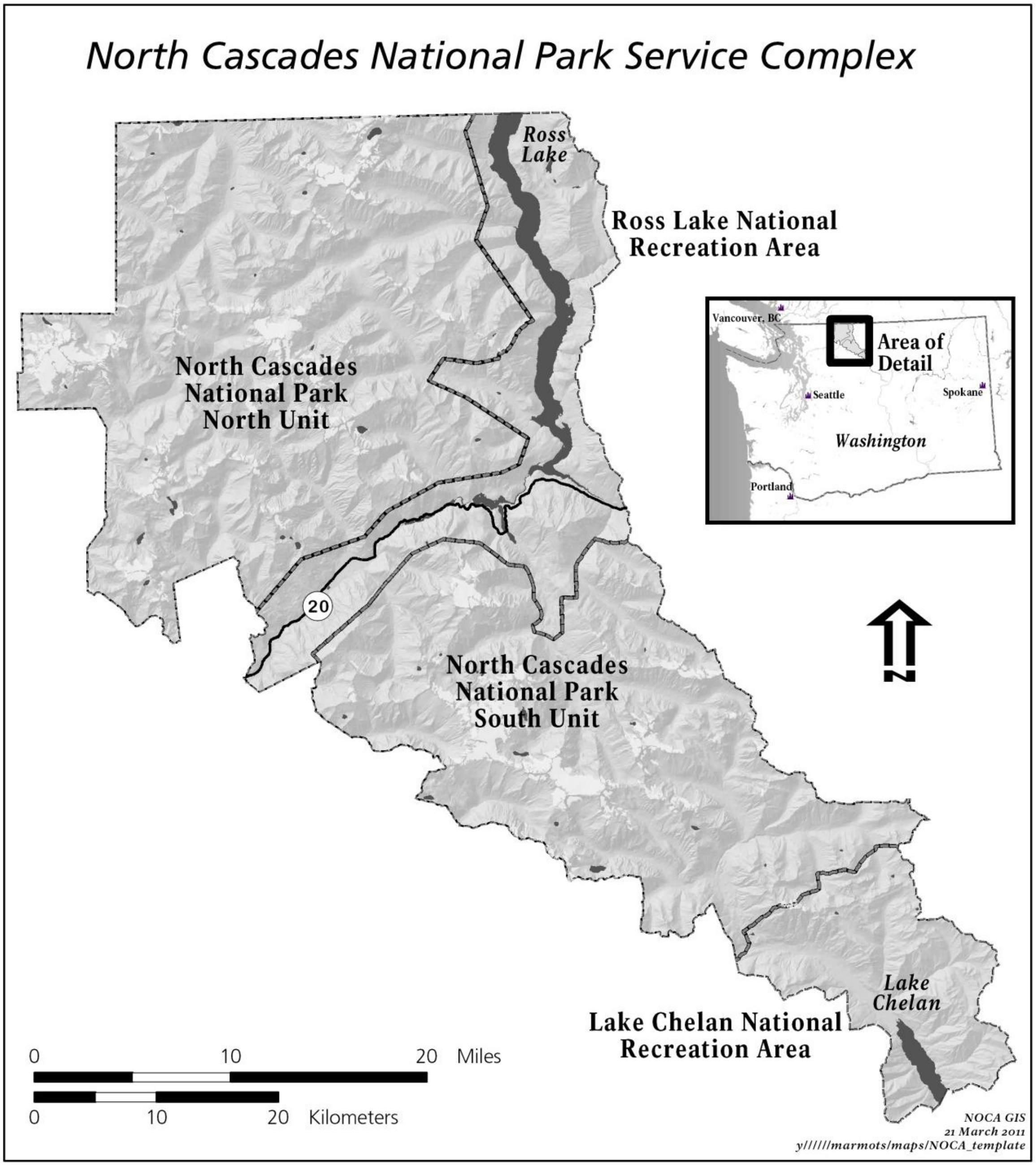

Figure 1. Map showing location of North Cascades National Park Complex, consisting of Ross Lake National Recreation Area, Lake Chelan National Recreation Area, and North Cascades National Park.

Methods

Sampling Design

Field surveys were conducted for two summers from late June through mid-September 2007 and 2008. Techniques and suggestions were extracted from other regional marmot researchers to develop a non-invasive and cost effective inventory protocol to meet study objectives while being adaptable to a wilderness environment.

Suitable habitat for marmots in NOCA was loosely defined as meadows above 1,219 m elevation. Habitat selection was based on 57 m resolution Level 2 vegetation and cover types from the 1986 Landsat TM North Cascades Grizzly Bear Ecosystem Evaluation product (Almack et al 1993). Ten vegetation classes were used in identifying marmot habitat to be surveyed (Appendix A). A park-wide systematic grid of points on all trails above 1,220 m was then developed using Geographic Information Systems (GIS). Spacing of these points on the GIS map was every 1 km. This produced 128 origination points, of which 48 points were randomly selected for sampling and numbered from 1-48. If two random points were geographically located adjacent to each other, then the highest numbered one was tossed and replaced by another random point in firing order. To avoid having more than one point in any given meadow, some points were eliminated. This process reduced the number of origination points to 31. Each point was used as a geographic reference for the survey site name (see Appendix B for site names and coordinates). The intention was to sample as many of the 31 survey sites as possible in 2007, knowing that it was likely we would not get them all done. Those sites not done in 2007 were then scheduled for completion in 2008, along with some repeat surveys of sites sampled in 2007. Survey sites were reviewed and habitat verified with aerial photos before going to the field and again while in the field as part of a ground-truthing process.

Survey sites consisted of a series of point count stations spaced 400 m apart with the first station at the origination point. Surveyors hiked to the origination point and then established subsequent points (hereafter referred to as point-count stations or stations) spaced 400 m apart along the trail in both directions (providing there was available suitable habitat) from the origination point. The 400 m distance between points was measured using a hand-held Global Positioning System (GPS) unit (Garmin Etrex Vista®). The actual location of the point count station was sometimes adjusted in the field to account for the best view spot to survey the nearby meadow. Once the point count station was established, the coordinates were recorded in Universal Transverse Mercator (UTM), NAD 83 format using the hand-held GPS unit. Point-count stations were added and surveyed every 400 m from the origination point until there was no more suitable meadow habitat available or until the allotted 5-hour survey period from 0700-1200 expired.

Based on crew size and available time, 23 sites were targeted to be surveyed one time each during the summer of 2007. Field work began in late June and continued through mid-September. This time frame coincides with spring snowmelt offering hiking access to the high country and also takes into account the beginning of the winter hibernation period, as observed for hoary marmots in the southern Cascades of Washington (Barash 1976). About 11 weeks of actual field time was anticipated after allowing for a week of employee training and foul weather days. This meant achieving a goal of about two survey sites per 4-5 day work week. Generally, a site was hiked into on a Monday, camp was established, location of the point count stations were evaluated or established if time allowed, and then actually surveyed the following morning.

Where possible, origination sites were organized into clusters which could then be targeted for completion with one field outing. This strategy helped to maximize efficiency and reduce physical demands on the crew. Where this approach was not possible or multiple sites were limited in proximity, camp would have to be moved more readily to an entirely different area with nearly a full day of travel time accounted for.

In 2008, the goal was to survey the remaining eight of the 31 total sites at least once, plus some repeat visits to a subset of sites. Repeat surveys were conducted to investigate detection probabilities aimed at determining how many visits might be necessary before marmot presence could be confirmed and to note any variability in count numbers. These additional visits included 1.) repeat four of the eight new 2008 sites twice to test for intra-year variability in presence and counts; 2.) repeat, on one occasion, four sites that had no sign of marmot presence in 2007 to test for inter-year variability in presence and abundance; 3.) repeat, on two occasions, four sites that were occupied in 2007 to test for both intra and inter-year variability in occupancy and counts. This accounted for 16 individual sites to be surveyed in 2008. For those sites that were repeated twice in the same year, only counts and age classifications of the survey having the greater count number were included in summary tables and analysis for this report.

Data Collection

Marmots are known to experience a bimodal activity period during morning and late afternoon hours (Holmes 1979, Bryant 1998). Surveyors attempted to survey between 0700 and 1200 to coincide with the morning activity rhythm. Most all sites were surveyed during the morning hours, but for either logistical efficiency or experimental reasons, surveyors did sample a subset of sites during the late afternoon activity period. A 30-minute survey period was used as a standard allotment of time at each point count station. The number of point counts stemming from each origination point was not standardized and varied according to meadow area. In some instances the survey deliberately started slightly before 0700 or extended beyond 1200, usually due to the logistics of gaining access to the survey area by the preferred start time, encountering more difficult terrain that required an increase of time to hike between stations, or from an unusually greater number of point count stations established along the survey transect due to larger meadow patch size.

Field methods involved scanning meadows and boulder fields with binoculars while looking and listening for marmots. A site was considered occupied by either direct visual detections or audible marmot whistles. Occasionally, when no marmots were seen or heard in a site, surveyors would search the meadow for presence of burrows or fresh marmot scat to gain possible evidence of recent activity. However, intensive ground searches as part of the standard sampling method is not being advocated, given the rugged topography of the landscape coinciding with safety concerns and extra time requirements.

Numbers of individual marmots were recorded from each point count station. Marmots were classified as adults, yearlings (1-2 year-olds) or juveniles (young of the year), based on size, pelage color and behavior. Adults were much larger in size than yearlings or juveniles and tended to have darker coloration on the face and back with a deep brownish-colored tail. Yearlings were observed as medium-sized with somewhat lighter pelage coloring and were especially discernable when observed next to adults. Juveniles were identifiable by their overall light pelage coloring, small size and behavioral actions of actual or attempts to nurse. Counts of juveniles were feasible only after approximately July 1, when young first emerge from their natal burrows (Bryant and Janz, 1996). Marmots observed while hiking to survey sites or while walking between point count stations were recorded as opportunistic sightings, but not used directly in the final analysis of this report.

A separate colony was generally defined as all marmots directly observed or heard from any given point count station that were within 200 m (the mid-point between point count stations) of one another. However, we determined there could sometimes be more than one colony at a point count station, particularly when marmots were observed on opposite sides of the valley slopes, often with opposing aspects and considerable distance (>400 m) between detections. Most marmots would stay in their respective locations long enough to count them individually before they moved, thus minimizing the possibility of duplicating counts while assuring separate colonies were identified accurately to the extent possible.

Detection time, elevation, slope aspect, distance and azimuth to individual marmots were recorded (see Appendix C for blank field form). Distances to individuals were measured and recorded in meters using a laser range finder. Azimuth, or degree bearing, was recorded using a hand help compass. Distance and azimuth attributes were recorded to determine area surveyed and population density. Recording distance also served as a means to evaluate appropriate spacing between point counts to eliminate overlap of individuals, and to establish how far away one could reliably determine age classes. Elevation was measured with an altimeter in the field. Elevation was recorded at each point count station and not at the actual marmot location, owing to observer safety in accessing the precise marmot location and potential disturbance concerns. Aspect was measured using a standard field compass and was recorded for both visual and audio detections.

Sampling occurred in misty or drizzly conditions, but not during times of more persistent rain. Some flexibility was granted at each point count station in order to allow for the best vantage point that allowed for maximum visibility while minimizing disturbance to marmots.

A crew of two people and an occasional volunteer, whom remained consistent throughout each survey year, conducted the surveys. This consistency in personnel helped to minimize biases in level of observer experience.

Habitat Types

Dominant habitat type was recorded within a 25 m radius of any observed marmot. This assessment was usually done from a distance using binoculars, since it was often not necessary or the terrain was unapproachable to physically be at the precise marmot location. Broad classifications were used that matched eleven vegetation classes in our existing GIS vegetation map layer. These eleven vegetation types included heather, huckleberry, sedge/grass, forbs, moss, rock (boulder/talus), mountain ash (shrub), mountain hemlock, subalpine fir, larch and whitebark pine (see field form, Appendix C). This information was used to broadly describe habitat where marmots were found and to ground truth the GIS vegetation layer used when initially describing suitable marmot habitat.

Survey Area and Density

Total area surveyed at each origination site was determined by using the farthest distance from the observer that a marmot was detected (434 m) and using that number as a standard radius in drawing a circle, via GIS, around each point count station. An assumption was made that marmots could use all area within the defined circle and that all points were equally surveyable. The resulting circles formed an overall polygon, which was then calculated and represented as area in km^2. Marmot density for each origination site was determined by dividing the number of marmots detected by the area surveyed (km^2) per site. Thus, marmot density for each site was defined as the number of marmots per km^2.

Model Development and Statistical Analysis

A response variable, MARMOTS, was defined as the total number of marmots counted at each survey site. Four covariates and one interaction were defined for use in the modeling analysis. First, AREA was defined as the total area surveyed at each site. To calculate AREA, GIS ArcView 9 techniques were used to delineate a circle with a radius of 434 m around each point at each site to account for the maximum distance from each point that could be surveyed. All circles were then merged at each site to eliminate overlap and to calculate the total area surveyed for each site. Second, ELEV was defined as the average elevation of all point count stations within each survey site. Third, a categorical covariate, DIVIDE, was defined as the location of each site relative to the Picket Crest and Cascade Crest divides that influence precipitation, temperature, and vegetation patterns in NOCA. The covariate, DIVIDE, was classified into three categories as west, mid, or east. Fourth, a categorical covariate, YEAR, was defined as the year in which the survey was conducted (i.e., 2007 or 2008). Finally, because the effect of elevation may vary with the location of the site relative to the divides, an ELEV*DIVIDE, interaction was also considered.

Competing *a priori* hypotheses were developed and expressed as 18 Poisson regression models (Zuur et al. 2009) consisting of additive combinations of covariate main effects and interactions. Poisson regression techniques in R (R Development Core Team 2008, Zuur et al. 2009) were used to fit models and estimate covariate coefficients. A corrected Akaike's Information Criterion (AIC_c) value for each model was calculated, and ranked and selected for the top approximating models using ΔAIC_c values (Burnham and Anderson 2002). Finally, Akaike weights (*w*) for each model were calculated to obtain a measure of model selection uncertainty (Burnham and Anderson 2002).

Results

Survey Effort

Field crewmembers surveyed a total of 31 survey sites (23 in 2007 and 8 in 2008) from late June to early September 2007 and 2008 (Figure 2). A total of 242 marmots were detected at 19 of 31 (61%) survey sites (see overview in Figure 2). More detailed survey area maps and occupancy status for each origination site are illustrated in Appendix D. Of the 242 detections, 88% were visual sightings and 12% were marmot vocalizations. Marmot abundance, including adults, yearlings and juveniles, per site ranged from 0 to 25 individuals (mean = 7.8; SE = 1.5).

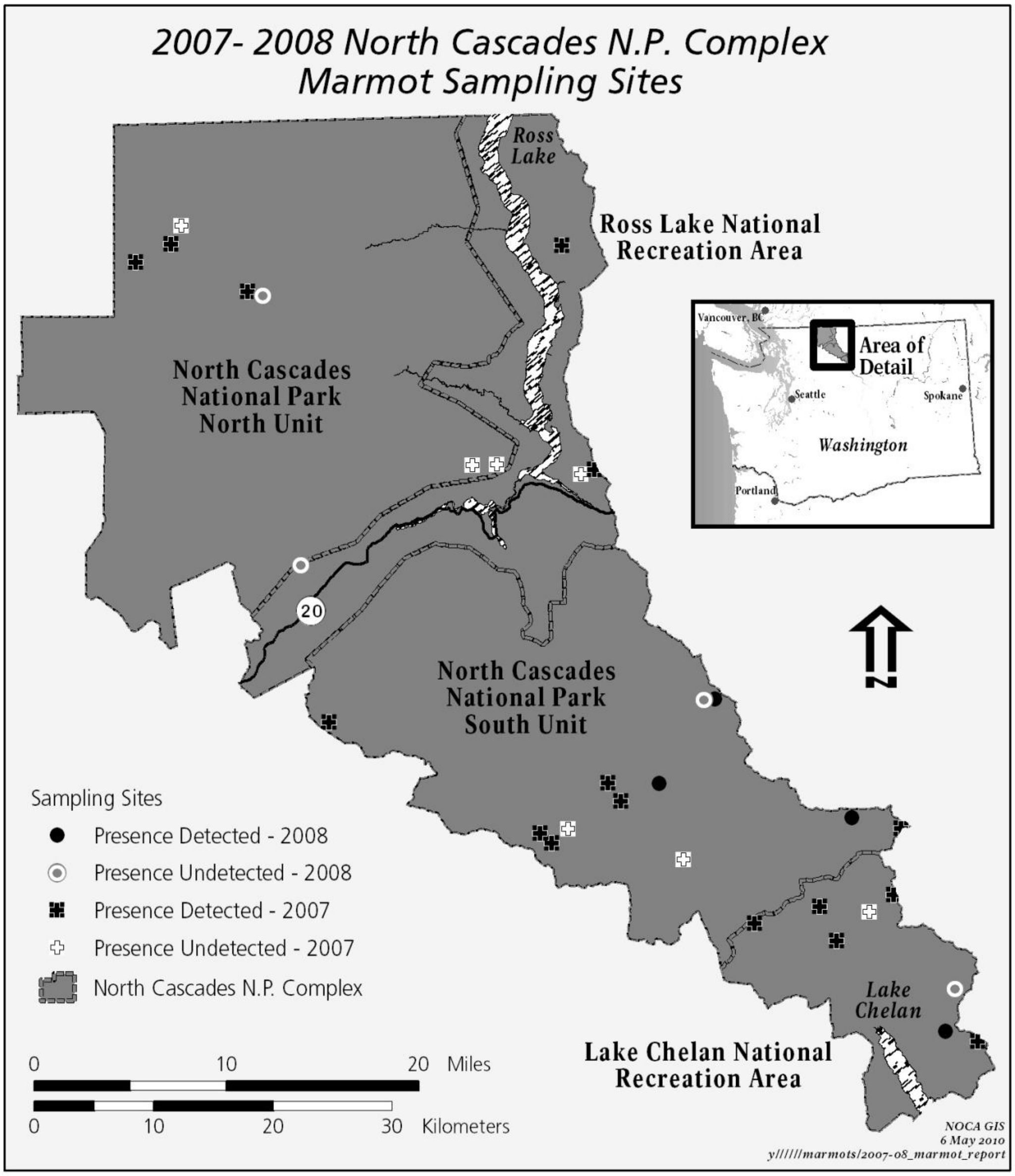

Figure 2. Location and status of marmot occupancy at survey sites during 2007-2008 marmot surveys in North Cascades National Park Complex. Survey sites were restricted to trail-accessed subalpine/alpine areas of the park complex.

From the 31 sites, surveyors established and sampled 123 individual point count stations along trail transects. The number of point count stations ranged from 2 to 9 (mean = 4) points per survey site. Of the 123 point count stations, 58 (47%) yielded marmot detections, ranging from 1 to 13 marmots (mean = 2.0; SE = 0.25) per point count. With a few exceptions, all marmots observed from each point count station were reported as an individual colony. One site (Fisher Creek Basin) had three point count stations (station numbers 3, 4 and 5) that each had one additional colony present, each separated by considerable distance (>400 m) and aspect. Hence, from this two-year effort surveyors identified what was thought to be 61 separate colonies, comprising a minimum of 242 marmots. A more comprehensive summary showing raw data collected from each of the 31 survey sites and the 123 point count stations is presented in Appendix E.

The configuration of new and repeated survey sites completed in 2008 is presented in Table 1. Four new 2008 sites were surveyed once with presence documented at one of four (Stilleto Peak) sites. Four new 2008 sites were surveyed twice with presence consistently documented at three of four sites (Fisher Creek Basin, North Fork Bridge Creek, Lake Juanita) on each of the two surveys. Presence was not confirmed at the fourth site (Thornton Lakes) in either of the two surveys. Four sites that were occupied by marmots in 2007 were again surveyed twice in 2008. Again, this resulted in confirmed presence at all four sites in each of the 2008 surveys, although there was slight variability in counts with each survey. Four sites that had no marmot detections in 2007 were selected to be resurveyed in 2008. Surveys at one of these four sites (Sourdough Mt.) yielded the presence of a single adult marmot in 2008, while presence remained unconfirmed at the remaining three sites.

Table 1. Configuration of survey sites sampled and occupancy results during 2008 marmot surveys in North Cascades National Park Complex.

New sites in 08, surveyed once	New sites in 08, surveyed twice	Sites surveyed once in 07 and once in 08	Sites surveyed once in 07 and twice in 08
Lone Mountain	Fisher Creek Basin	Copper Lake	Monogram Lake
Stilleto Peak	N. Fork Bridge Creek	Sourdough Lookout	Twisp Pass
Whatcom Pass E.	Lake Juanita	Sourdough Mt.	Purple Pass
Fisher Ck	Thornton Lakes	Basin Creek	Copper Lookout

Of eight sites that were surveyed twice in 2008, four (50%) showed an increase in count numbers on the second survey (Figure 3). Of these four sites, counts increased by an average of 27.0% (SE = 4.9) between the first and second survey. Additional counts of juveniles accounted for 64% of this increase. One site, (Juanita Lake), had a decrease in marmot detections on the second survey. This can likely be explained by suboptimal weather conditions, as there was intermittent rain and hail showers occurring that day. No marmots were detected during the second survey at two sites (Monogram Lake and Twisp Pass), which can best be explained by the late season survey dates where marmots were either spending more time in their burrows or were already in hibernation. The Thornton Lakes site resulted in no marmots detected on either of the two surveys for reasons not clearly understood.

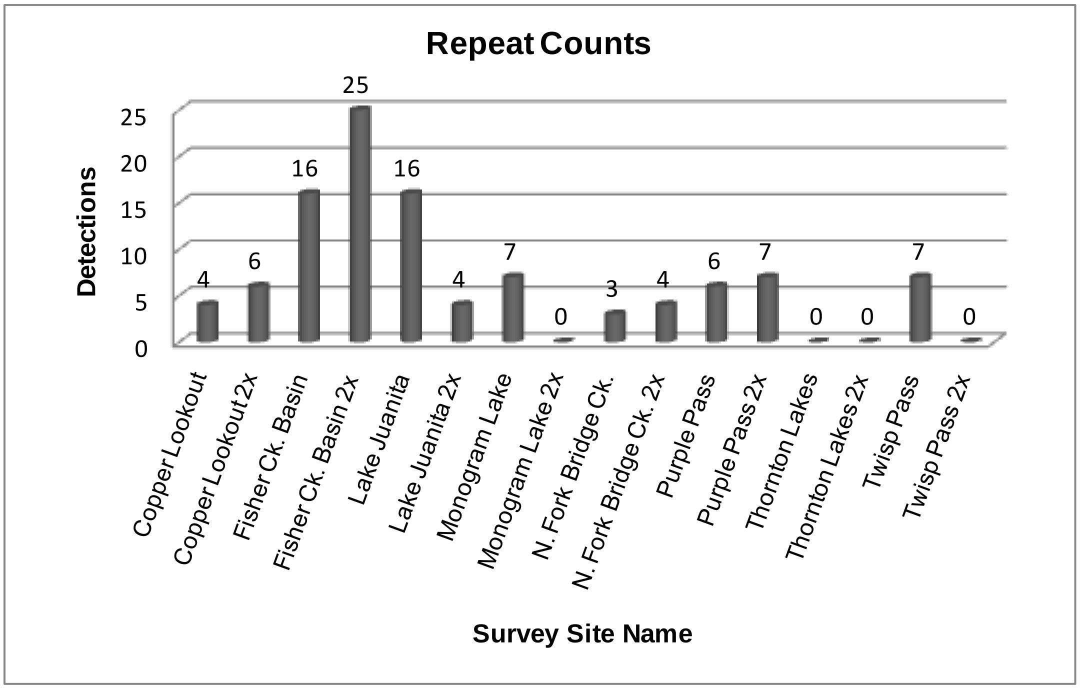

Figure 3. Number of detections at repeated sites during 2008 marmot surveys in North Cascades National Park Complex (2x indicates second of two surveys).

Age Classifications and Abundance Counts

Marmot age classifications consisted of 145 (60%) adults, 33 (14%) yearlings, 31 (13%) juveniles, and 33 (14%) unknown, for a total of 242 marmots (Table 2). Unknown age was associated with too great of a distance to be certain or vocalizations of marmots with the inability to visually observe the animal. Colony size, consisting of adults, yearlings, juveniles and unknowns ranged from 1 to13 marmots (mean = 3.6; SE = 0.26). Juveniles were observed at 20 of 61 (33%) colonies, ranging from 1 to 3 young per colony (mean = 1.6).

Table 2. Survey sites and counts by age class during 2007 and 2008 marmot surveys in North Cascades National Park Complex.

Origination Site Name	No. of Point Counts	No. of Colonies	No. of Adults	No. of Yearlings	No. of Juveniles	No. of Unknown	Total Marmots
2007 sites							
Monogram Lake	3	3	11	0	0	0	11
Sourdough Mt.	2	0	0	0	0	0	0
Sourdough Lookout	5	0	0	0	0	0	0
Jack Mt 1	4	0	0	0	0	0	0
Jack Mt. 2	4	4	10	4	2	0	16
Desolation Peak	4	4	6	4	2	0	12
South Pass	6	4	10	5	2	1	18
Rainbow Creek	4	3	8	1	0	0	9
Rainbow Ridge	4	0	0	0	0	0	0
Rainbow Lake	3	3	7	0	4	0	11
Purple Pass	9	5	13	0	1	10	24
Twisp Pass	5	2	6	0	0	1	7
Horseshoe Basin	3	0	0	0	0	0	0
Pelton Basin	3	3	6	4	1	4	15
Sahale Arm	5	5	11	4	2	2	19
Park Creek Pass	2	2	6	1	1	1	9
Park Creek Pass South	3	3	12	3	3	4	22
Copper Lookout	5	3	4	0	3	2	9
Copper Ridge	4	2	1	0	1	1	3
Copper Lake	7	0	0	0	0	0	0
Whatcom Pass	3	0	0	0	0	0	0
Goodie Ridge	3	0	0	0	0	0	0
McGregor Mt.	3	2	3	0	2	2	7
[1]2008 sites							
Whatcom Pass East	4	0	0	0	0	0	0
Fisher Ck.	3	0	0	0	0	0	0
Lone Mountain	3	0	0	0	0	0	0
Lake Juanita	4	3	10	3	0	3	16
Thornton Lakes	2	0	0	0	0	0	0
Stilleto Peak	5	1	5	0	0	0	5
[2]Fisher Ck. Basin	5	8	14	3	7	1	25
[2]North Fork Bridge Ck.	3	1	2	1	0	1	4
Totals	**123**	**61**	**145**	**33**	**31**	**33**	**242**

[1]Includes only the eight new sites surveyed in 2008.

[2]Sites were surveyed twice, showing the second (greater) of the two survey results here.

Habitat Characteristics

Habitat cover types most dominant at marmot locations were boulder/talus and forb meadow, 71% and 21% respectively (Figure 4). Marmots were often observed loafing on the largest sized boulder (> 1 m diameter) with several smaller sized boulders or talus (0.2 to 1 m; Smith and Weston) adjacent to the sighting. These small boulder and talus patches were generally surrounded by meadow areas rich in forbs and grasses. A small number of marmots were detected where the dominant habitat type was heather, huckleberry, shrub or larch, but on these occasions there was also the presence of forb meadows interspersed with boulder/talus habitat types within close proximity. Marmots were not found in meadows with bedrock or talus consisting of small-sized rocks (< 0.2 m) having thin coverage or minimal depth. They were also not found in rock outcrops, unless there was boulder/talus nearby, in which case they were observed using the rocky substrate for burrowing while using the outcrop as a vantage point.

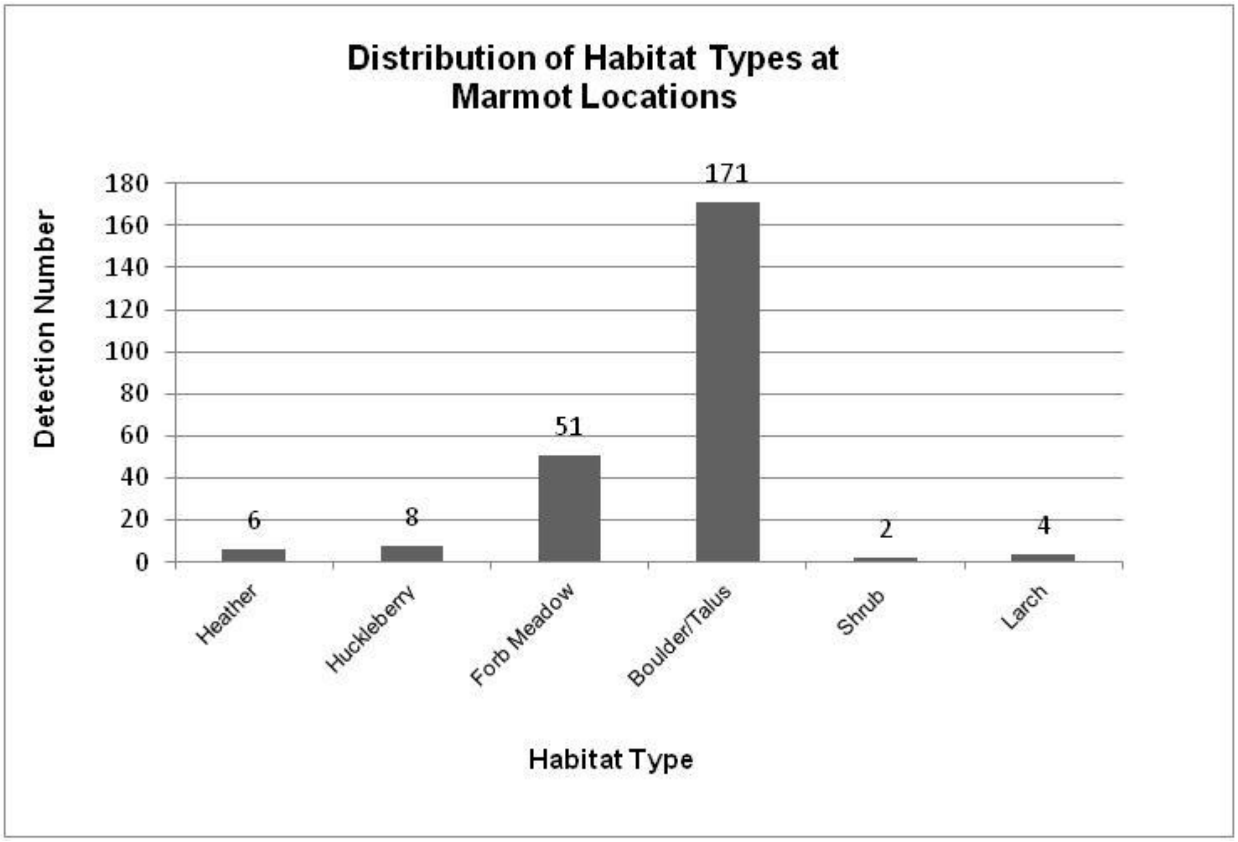

Figure 4. Habitat type within 25 m radius of where marmots (n=242) were detected during 2007-2008 surveys in North Cascades National Park Complex.

All point count stations that were sampled (n=123) ranged in elevation from 1,158 to 2,198 m (mean = 1,736 m; SE = 20.7). Point count stations with marmot detections ranged in elevation from 1,158 to 2,115 m (mean = 1,789; SE = 28.7). Occupancy was highest in the 1,800 to 1,899 m and 2,000 to 2,099 m intervals, consisting of 60 and 83 percent occurrence respectively (Figure 5). There was greater occupancy as elevation increased, peaking at the 2,000 to 2,099 m range and then decreasing in the 2,100 to 2,199 m range. Because sampling was not done above 2,199 m, it is not known if this downward trend would continue or if there is a possible upper elevation threshold for marmot presence in the 2,000 to 2,099 m range. The low end of the overall elevation range was located at the first point count station at the North Fork Bridge Creek site, which was slightly below our initial sampling design query of meadow habitat above 1,219 m, but was included because it was part of the contiguous meadow for this site. This was also the only point count station that marmots were detected in this survey site. The upper end of the range occurred at the Stilleto Peak site.

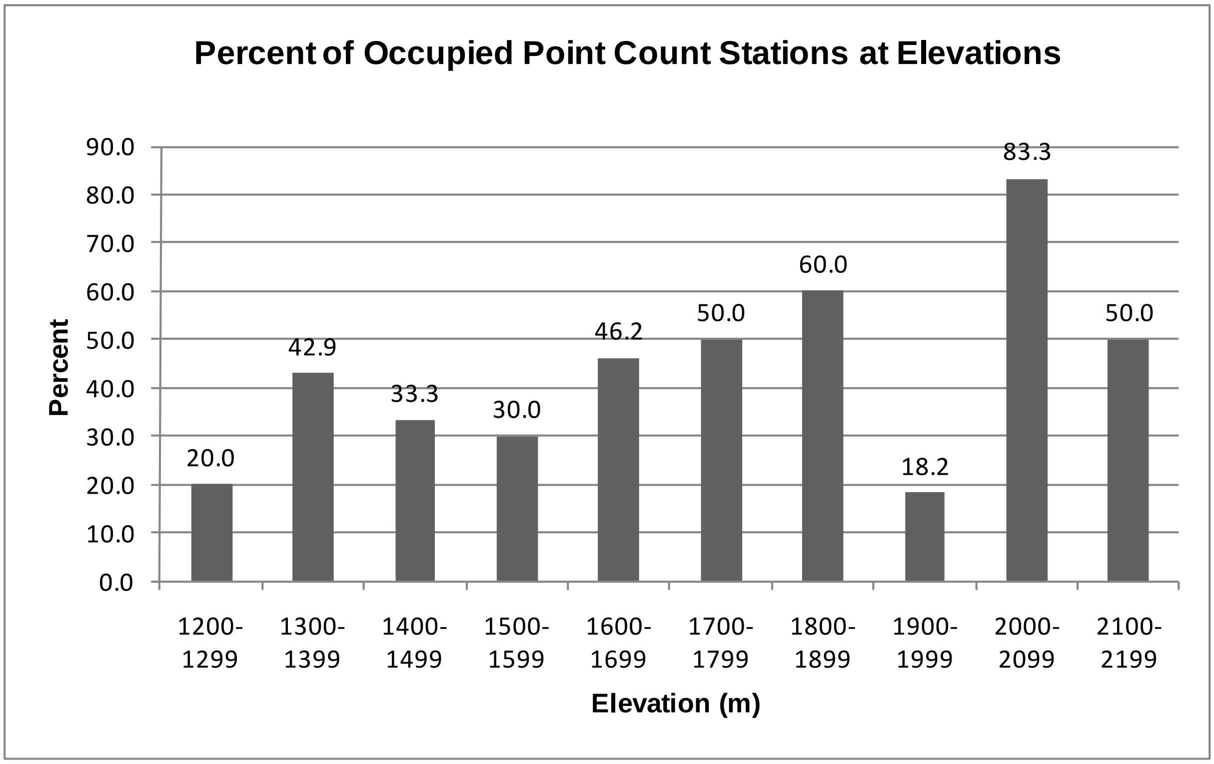

Figure 5. Percent occupancy of point count stations within elevation gradients during 2007-2008 marmot surveys in North Cascades National Park Complex.

Aspect of the slope (N, NE, E, SE, S, SW, W, NW) was recorded where marmots were detected. At a broader scale of analysis, the eight aspects were lumped into just the four cardinal directions (N, S, E, W). This outcome showed 54.5% of occupied point count stations had marmot detections strictly on southerly-facing slopes (Figure 6).

Sampling Time Frame

Some survey sites were completed in considerably less time while others consumed or slightly exceeded the full complement of time from 0700 to 1200. This variability was generally owing to terrain conditions, size of survey area or inclement weather requiring a wait period. For example, at one site in particular (Desolation Peak), surveyors encountered heavy fog early in the morning delaying the survey start time and consequently extending the end time to 1450 (Figure 7). The greatest percentage of marmot detections (62%) occurred between the hours of 0900 and 1200, with the single hour of 1000 to 1059 accounting for nearly 22% of detections (Figure 7). Sixty-one percent of marmot detections were recorded within 10 minutes of the survey start time and 80% were recorded within 20 minutes.

One site, Pelton Basin, was surveyed in the late afternoon instead of the morning. This was a small attempt to evaluate the effectiveness of conducting surveys during the afternoon bimodal activity period. The hour of 1700 to 1759 was found to be the most productive, accounting for 11 of 15 (73%) late afternoon detections, although the sample size was limited to just one survey site (Figure 7). However, marmots were observed to be more dispersed during this activity period, which required much more diligence in avoiding duplicate counts.

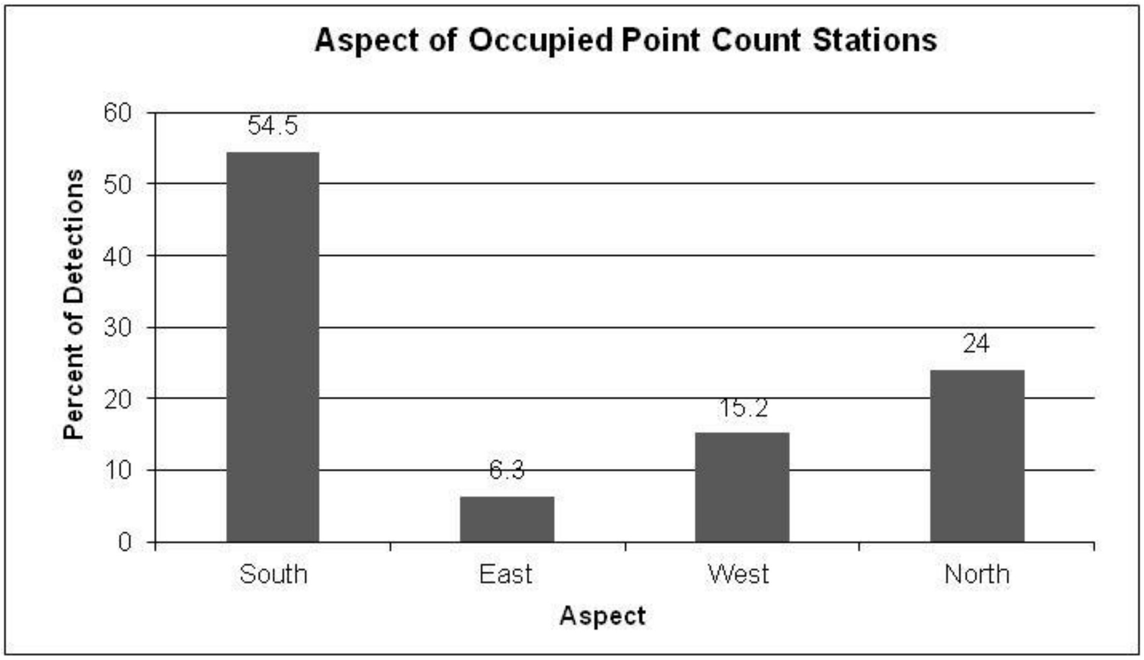

Figure 6. Aspect of occupied point count stations (n=58) during 2007-2008 marmot surveys in North Cascades National Park Complex.

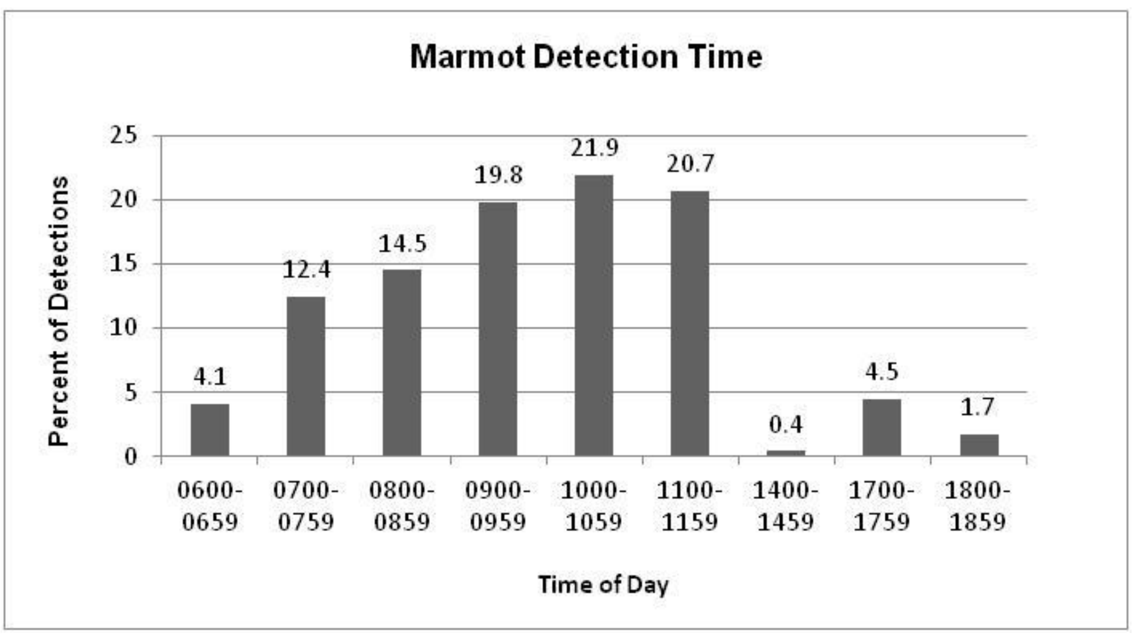

Figure 7. Time of day of detections during 2007-2008 marmot surveys in North Cascades National Park Complex.

Detection Distance

The distance from the observer to the individual marmot was recorded from each point count station that had marmot detections (Figure 8). Distances ranged from 8 to 434 m (mean = 169.0; SE = 7.3). Nearly 75% of detections occurred within 200 m of the observer with the 51-100 m range accounting for 22.3% of all detections.

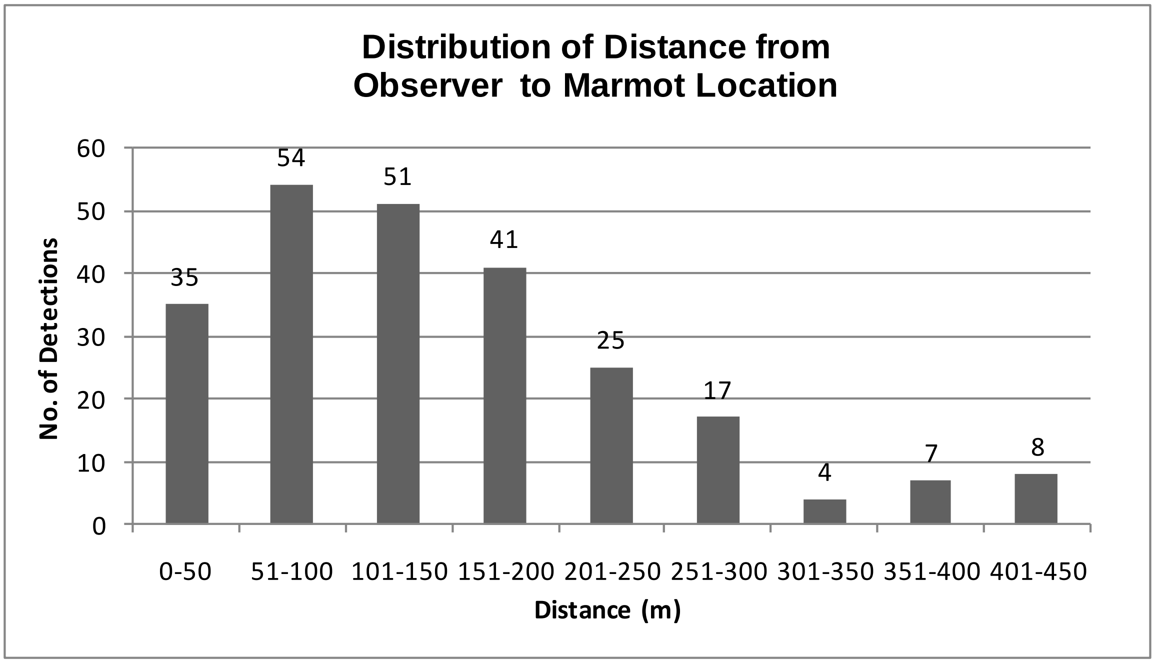

Figure 8. Detection distance from observer to marmot location (n=242) during 2007-2008 surveys in North Cascades National Park Complex.

Survey Area and Density

Total area surveyed for the 31 origination sites was approximately 48.29 km^2 (4,830 ha or 11,935 acres). This included all area within the 434 m radius at each survey site. It was considered beyond the scope of this study to define what would be considered non-suitable habitat or account for variations in topography and trees that might make certain points more surveyable than others. Area surveyed at individual origination sites ranged from 0.85 to 3.39 km^2 (mean = 1.56; SE = 0.11; Appendix F). Marmot density (including adults, yearlings, unknowns and juveniles) per origination site ranged from 0 to 18.5 marmots/km^2 (mean = 5.03; SE = 0.097; Figure 9). Sites having notably higher densities included Park Creek Pass South, Pelton Basin, Fisher Creek Basin and Lake Juanita consisting of 18.5, 17.6, 12.2 and 11.5 marmots/km^2, respectively. All of these sites are located east of the Cascades crest.

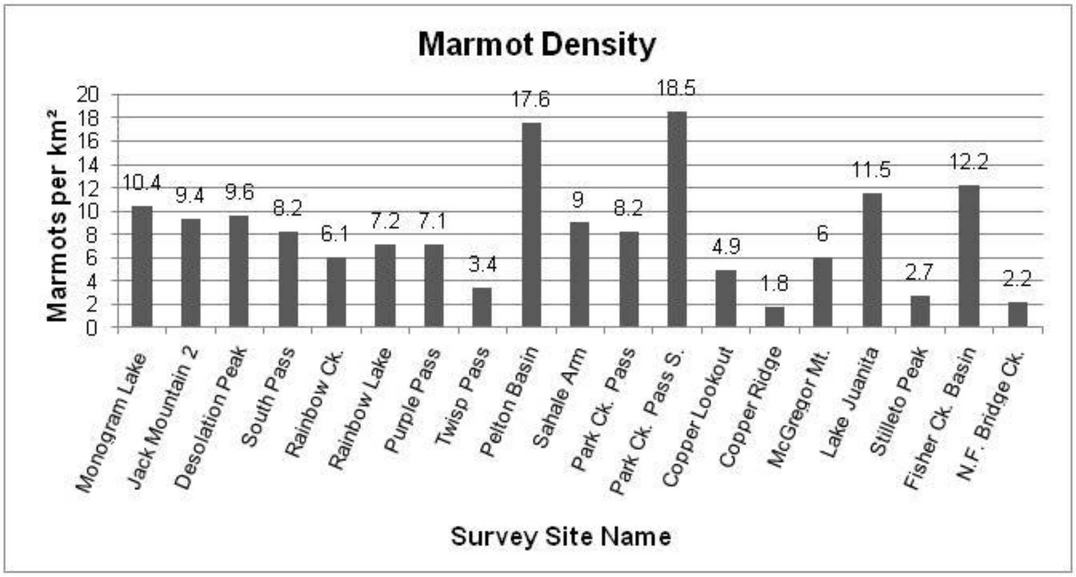

Figure 9. Marmot density at survey sites with detections during 2007-2008 surveys in North Cascades National Park Complex.

Statistical and Modeling Analyses

There was one top approximating model with $\Delta AIC_c < 2$ that had a $w = 0.775$ and an explained deviance (Zuur et al. 2009) of 24.3% (Figures 10-15). The second best model had an $\Delta AIC_c = 3.35$ and $w = 0.145$. The top model contained a significant, positive AREA covariate (estimate = 0.40; 95% confidence interval [CI] = 0.19, 0.61) and ELEV*DIVIDEwest (estimate = 0.002; 95% CI = 0.001, 0.004) interaction that each had coefficient confidence intervals that did not overlap zero. The top model also contained a significant, negative DIVIDEwest covariate (estimate = -14.38; 95% CI = -23.87, -4.88) with confidence intervals not spanning zero. Covariates contained in the top model that had confidence intervals that slightly overlapped zero included ELEV (estimate = 0.0002; 95% CI = -0.00002, 0.0004) and DIVIDEmid (estimate = -2.20; 95% CI = -5.02, 0.63), and an ELEV*DIVIDEmid interaction (estimate = 0.0004; 95% CI = -0.0001, 0.0009).

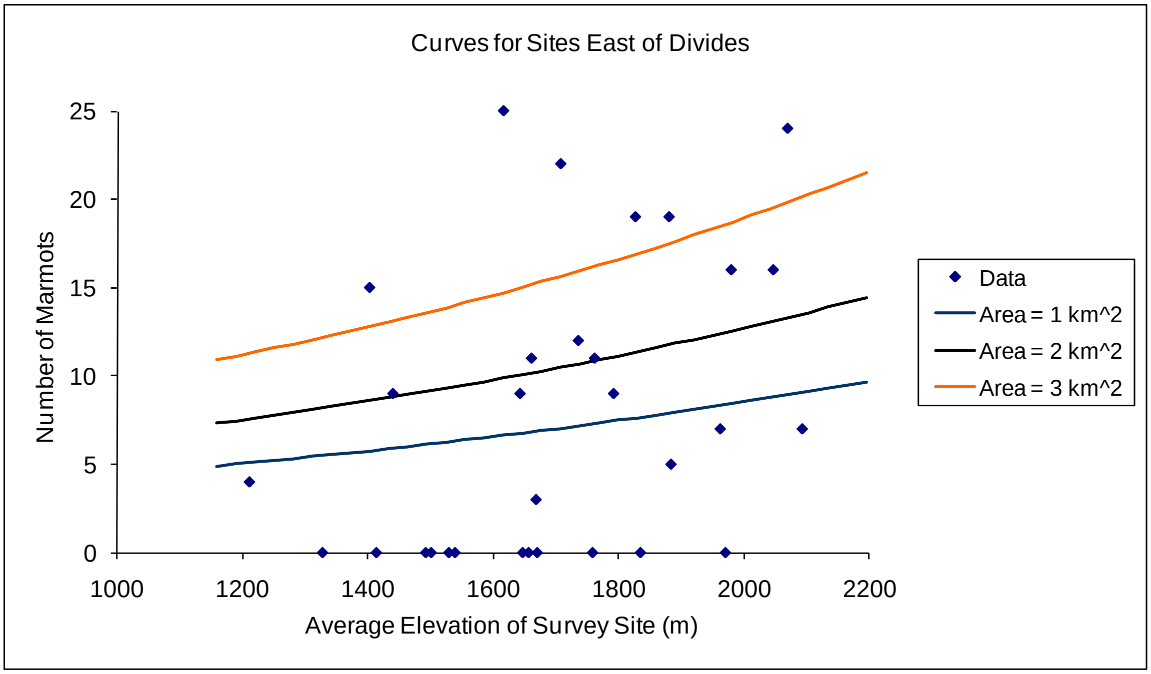

Figure 10. The relationship between the number of marmots detected and average elevation of survey area and area surveyed at sites east of divides.

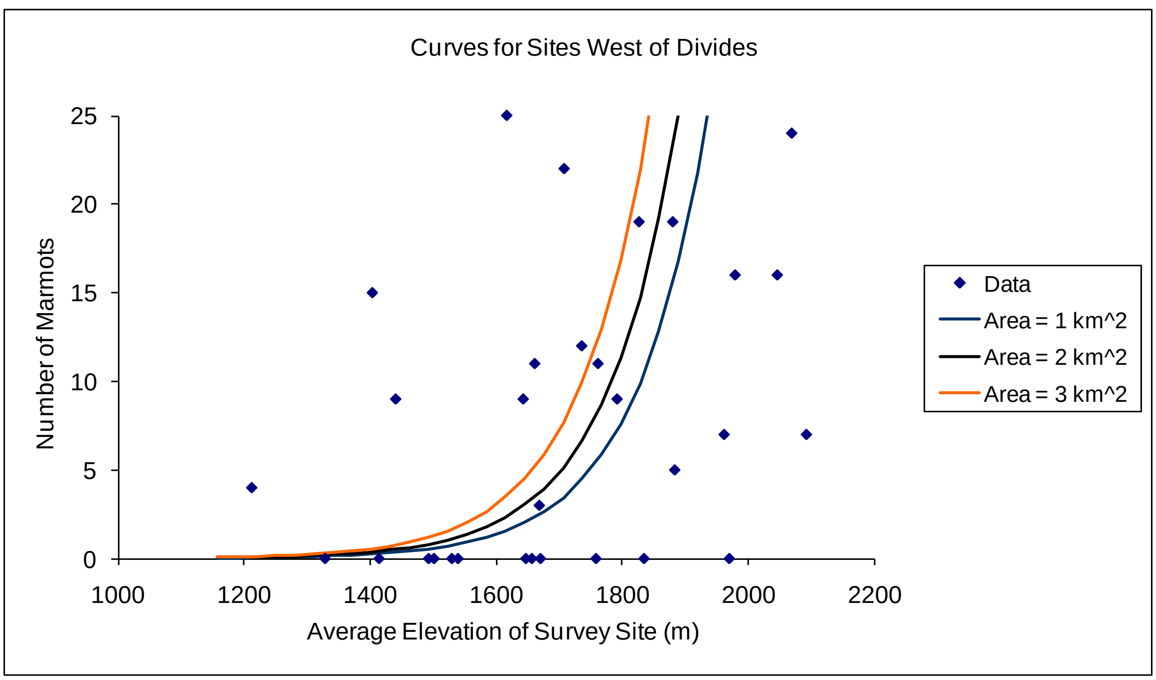

Figure 11. The relationship between the number of marmots detected, average elevation of survey area and area surveyed at sites west of divides.

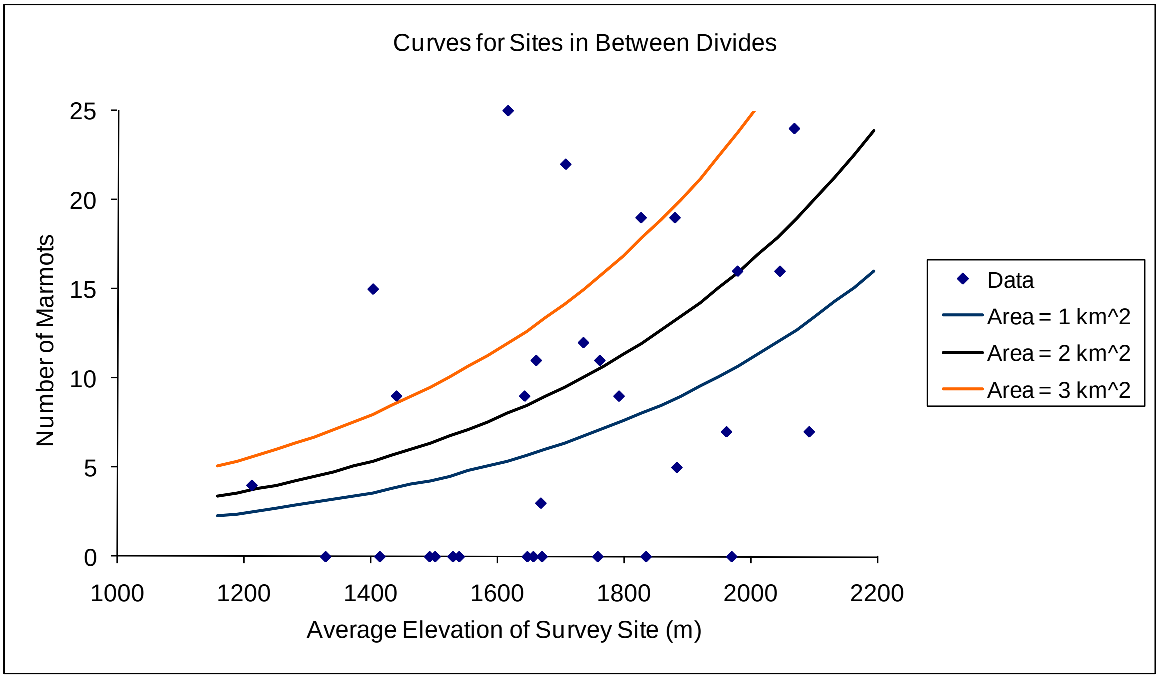

Figure 12. The relationship between the number of marmots detected, average elevation of survey area and area surveyed at sites in between divides.

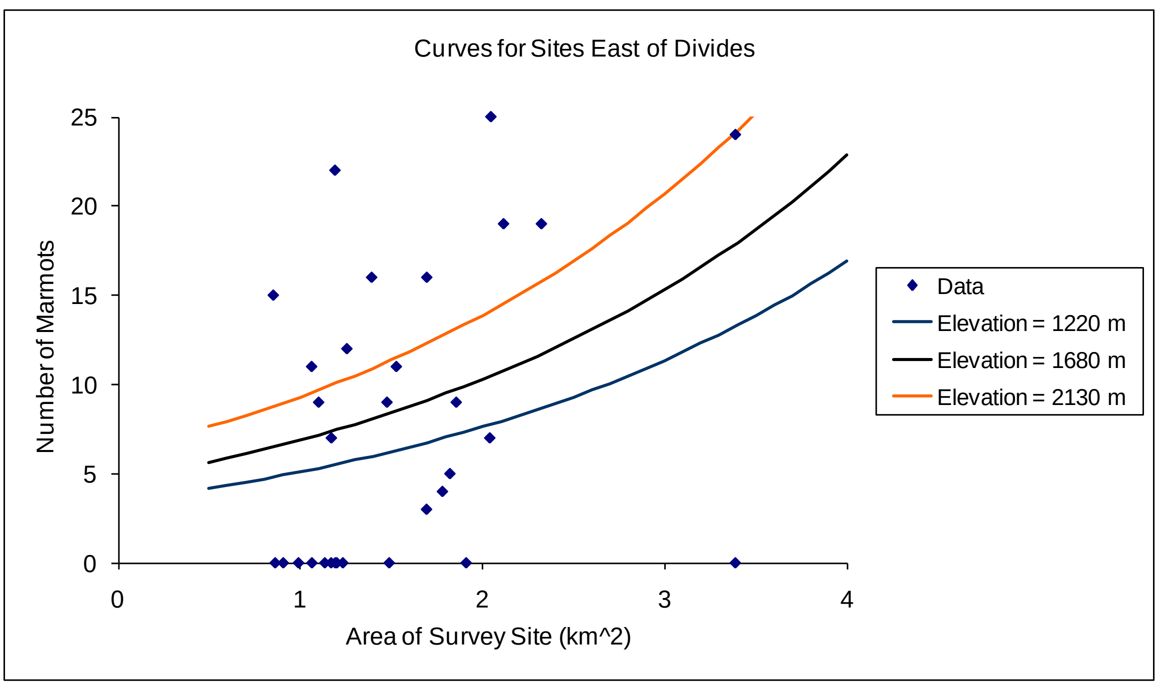

Figure 13. The relationship between the number of marmots detected, area of survey site and elevation at sites east of divides.

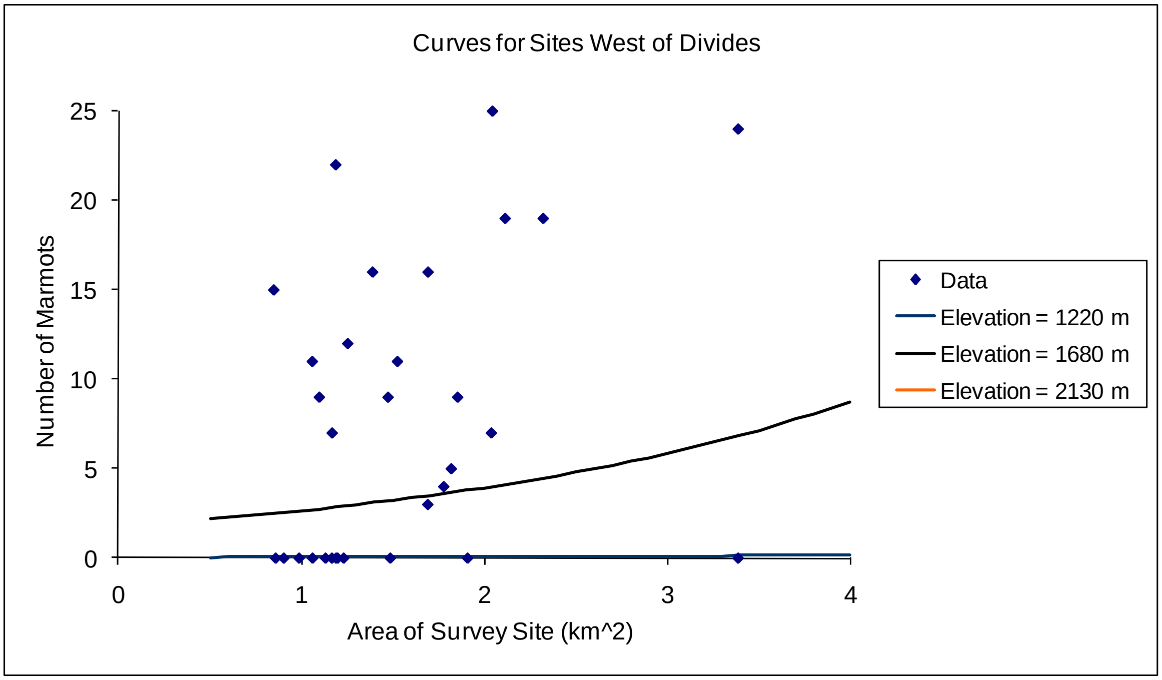

Figure 14. The relationship between the number of marmots detected, area of survey site and elevation at sites west of divides. The model curve for an elevation of 2,130 m is not depicted because its predicted abundance values were higher than 25 marmots.

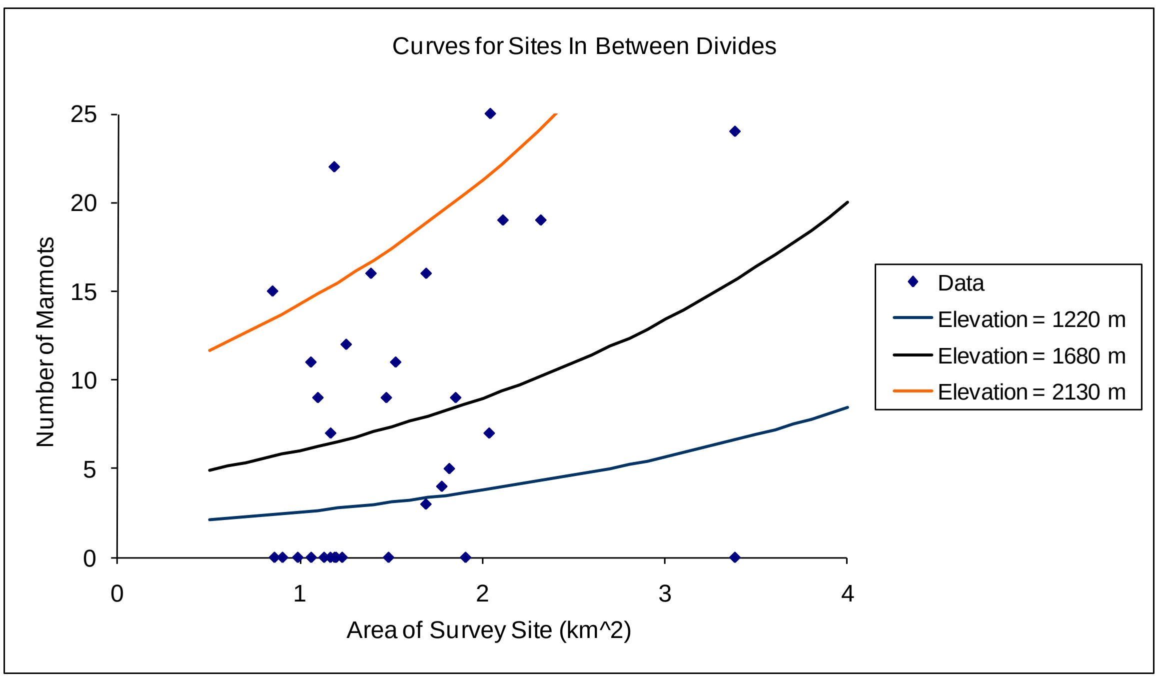

Figure 15. The relationship between the number of marmots detected, area of survey site and elevation at sites in between divides.

Other Opportunistic Species Detected

Observations of other alpine mammal species were recorded including, but not limited to, golden mantled ground squirrel, (*Spermophilus lateralis*), Townsend's chipmunk (*Tamias townsendi*), pika (*Ochotona princeps*), and Columbia ground squirrel (*Spermohilus columbianus*). Observations were recorded in the comments section of the field data form and compiled in Appendix G. A separate spreadsheet was developed and stored for all pika observations, due to the heightened awareness this species has recently attained and the need for these data. Detections of Columbia ground squirrels were the first reported occurrence records for this species in the park complex (NOCA wildlife database 2009).

Discussion

Distribution and Abundance

This study provided the first systematic inventory of hoary marmot distribution and abundance in NOCA. Surveyors counted 242 marmots at 61% of survey sites, suggesting the species is fairly abundant in NOCA. Survey data suggest marmot habitat is spatially discrete and their distribution is highly fragmented, consistent with metapopulation theory. The results of this survey establish a baseline of marmot distribution and abundance in NOCA that can be used to evaluate future conditions of the species. Results demonstrated that this particular approach to locating and counting marmots was cost effective, noninvasive, amenable to working in a wilderness environment and successful in meeting our objectives. Marmot habitat was easily identified using GIS applications and recognizable in the field. Marmots were found to be very conducive to direct visual counts, as they are highly visible, diurnal and quite tolerant of close observation. This further supports the notion that marmots are a relatively easy mammal to study as a suitable indicator species for assessing alpine ecosystem integrity (Karls et al. 2004). This relative ease of detection may also be favorable in using volunteers to assist with surveys.

Marmot abundance at survey sites was correlated with multiple factors. First, as predicted, abundance was positively correlated with the area surveyed, suggesting larger areas provide more resources to support greater numbers of marmots that may persist in one or more colonies. Abundance was negatively correlated with sites located west of the divides, but positively correlated with an interaction between elevation and sites located west of the divides. The negative main effect indicates that marmot abundance was lower at sites west of the divides than at those located east or in between the divides. In general, west side sites are likely to receive greater snowfall in winter and precipitation during summer (Sumioka et al. 1998). These factors are known to affect the timing of vegetation emergence in spring and the duration of the growing season in summer (Van Vuren and Armitage 1991, Inouye et al. 2000, Dunne et al. 2003). In turn, these factors may affect marmot survival and reduce the likelihood of having larger colonies because of resource limitations during a shorter growing season. However, the interaction suggests higher elevation survey sites supported more marmots than lower elevation sites west of the Cascade crest, which may be the result of interacting factors directly or indirectly affected by elevation. Elevation can act as a surrogate where other factors such as forage availability, snowpack, snowmelt, and plant distributions are likely to affect marmots and have different associations with elevation with respect to divide.

Habitat Associations

Marmots were located at elevations ranging from 1,158 to 2,115 m. This corresponds somewhat closely to nearby Olympic marmot colonies typically found at elevations between 1,500 and 1,750 m (Barash 1973). Habitat data collected showed 92% of detections were associated with boulder/talus (0.2 to >1 m diameter) and forb meadows as the dominant cover types, suggesting these components play important ecological roles and are key attributes when describing suitable marmot habitat in NOCA. The strong affinity to these two cover types is consistent and rather predictable in other studies of hoary marmots (Barash 1974, 1980). The heterogeneous distribution of these boulder formations with surrounding forbs resulted in a corresponding patchy distribution of marmots. Marmots were not found in meadows composed of bedrock or a thin layer of small-sized talus, apparently for reasons Svendsen (1974) describes as soil types that prohibit the development of burrows.

Marmots were detected at all aspects, but with the greatest frequency (55%) on south to west-facing slopes. Barash (1974) notes a preference of southern slopes for Olympic marmot colonies at 64% of study sites, while Bryan and Janz (1996) report Vancouver Island marmots favoring south to west-facing slopes at 74% of sites. This preferred slope orientation suggests there may be factors such as timing of snow melt, vegetation types or availability of forage that make southern exposure more favorable to marmot presence (Barash 1973). We did not record the degree of slope at marmot locations, which could be another contributing factor in habitat selection.

Aside from insights regarding broad habitat descriptions, no detailed investigation was conducted that might explain why marmots went undetected at some sites. One must be cautious and recognize that it is plausible marmots were present, but went undetected. It is also possible, given the metapopulation dynamics associated with marmots, these sites were once occupied, but have since become unoccupied, and if so, little is known of the disappearance rate or persistence thresholds and how much of this may be natural or related to other factors such as habitat limitations, predation, climate change or recreational activity.

Detection Rates

Surveyors had good success in counting marmots during the morning bimodal activity period, consistent with other marmot surveys conducted in the region (Griffin 2007, Witczuk 2007). Although some studies suggest conducting surveys prior to 1100 (Bryant and Janz 1996), results of this study show a sizeable number of detections (20.7%) were during the hour of 1100-1200. In addition to time of day, Barash (1973, 1989) reports marmot daily activity patterns to be dependent on weather and time of season. For example, during cool and rainy periods they may switch to a single mid or late afternoon activity period. In view of that, and for reasons of maximizing sampling efficiency, surveyors experimented with conducting surveys during late afternoon hours and did find marmots to be active during this period. However, it appeared marmots were more dispersed and moving about more within their respective territories during this time frame, thus increasing the possibility of duplicate counts. It should be noted that this particular sample size included only one survey site and was too small to determine if there was any real advantage or disadvantage to surveying during the late afternoon activity period.

Repeat surveys were incorporated within and across years at some sites to investigate capability of detection in determining site occupancy and to explore variability in count numbers. Although the repeated sample size was small and absent of robust statistical analysis, high detection rates were experienced from the few resurveyed sites. Eleven of 12 sites (92%) that were either surveyed twice within the same year or across two years resulted in presence confirmed on each of the two surveys. The remaining one site found to be unoccupied in 2007, but occupied in 2008, constituted a newly discovered colony and may have been a result of either recolonization, or the animal was actually present during the 2007 survey and simply went undetected. Surveys of Olympic marmots found the possibility of determining marmot presence at individual sites to be quite high also; 92% or greater with one survey (Griffin 2007, Witczuk 2007).

Count Limitations

Count numbers recorded represent a minimum computation of marmot abundance and likely under represent actual population numbers at surveyed sites. Because marmots have a complex burrowing system and they have an inherent tendency to use them as refuge from warm temperatures and predator avoidance (Barash 1973), it is likely some marmots were underground during the survey and were missed. This presents a detectability issue and variation in counts is further confounded by time of season, time of day, and weather conditions. For example, population counts of Vancouver Island marmots were greater in May, June and July than in August and September (Bryant and Janz 1996, Bryant 1998). Suggested reasons for these differences may be attributable to lower vegetation height in early summer offering increased visibility for the observer or declining marmot numbers during the summer, owing to dispersers that leave the colony and predation losses. Activity patterns have also been known to change in late summer, such as progressively shorter time spent above ground during the day and elimination of an afternoon rest period, as observed in a colony of hoary marmots in eastern Washington (Taulman 1990). Despite these concerns, Bryant (1998) reports good success with visual counts as an index of Vancouver Island marmot abundance and this was the primary method that eventually disclosed the dramatic decline of the species. He also noted that with three repeated visits nearly 73% of marmots present will be counted, although habitat features, such as clearcuts where some Vancouver Island marmots are found, may make observations more difficult and influence counts. Because observations from this study were mostly in more open meadows with relatively short to medium height vegetation, it might be expected that even higher detection rates could be achieved with fewer repeated counts. Of course this would take a larger sample of repeat surveys than currently available to elucidate this information for marmot abundance in NOCA.

Juvenile marmots were also probably under represented, since they emerge later than adults from early to mid-July (Bryant and Janz 1996, Taulman 1990). Surveyors first observed juvenile marmots during this study on 17 July 2007 and some sites were surveyed prior to this date, which may have excluded juveniles from being counted. They may emerge somewhat earlier, but because surveyors were engaged in sampling two sites that resulted in no marmot detections the week before, we were not able to pinpoint exact emergence dates. Nonetheless, a slight increase in count numbers was found at 50% of repeated survey sites, which also corresponded with increasing date. This may be a result of pure chance or could be due to the timing of juvenile emergence, but without sufficient repeated surveys it is difficult to say whether this factor had much of an impact on overall abundance counts. Moreover, it has been suggested that given the high mortality rate of juveniles (about 50% make it the first spring) that they could be ignored in counts as their numbers may be almost irrelevant (S. C. Griffin, personal communication). Also, it is important to acknowledge that not all viewing potential from point count stations was equal, given some meadows were larger and some had more obstructions than others (i.e., boulders, scattered trees, cliffs, gullies). Despite these limitations, using visual counts with the critical assumption that a fairly constant proportion of the population is detected each year, should provide for the detection of an increase or decrease in counts and give an indication of the magnitude of the population changes across time (Thompson et al. 1998).

Surveyors were quite confident that each marmot was counted as an individual without duplicating counts, given the general consistency of adequate space between individuals and their tendency to maintain this separation long enough to count each animal independently. However, it became more challenging to accurately determine which individuals comprised a unique colony. This uncertainty was confounded by not knowing what constitutes a minimum colony range for marmots in NOCA. The mean foraging area for a colony of hoary marmots in Alaska was 9.2 ha with each colony always having at least one contiguous neighboring colony

(Holmes 1984). Average colony range size of Olympic marmots was reported as rarely exceeding 2.0 ha, with several colonies often existing within 500 m (Barash 1973). In a separate study of Olympic marmots, Griffin (2007) describes approximate minimum colony range size of 0.56 ha. It would not be expected that the size of marmot activity areas would be exactly the same in the North Cascades given differences in topography, climate, and vegetation composition, but values from other studies do offer insight and approximations of what might be anticipated.

Surveyors recorded 61 colonies based on enumerating a separate colony from each point count station, with an exception at three point count stations each having an additional colony. This assessment was largely based on intuitive judgment, assuming marmots within very close proximity of one another were part of the same family unit. These results show mean colony size of 3.6 (range = 1 to13) with a mean of 1.6 (range = 1 to 3) juveniles per colony. Two other behavioral studies of hoary marmots, one at Mount Rainier National Park and the other at Glacier National Park, report average colony size of 10.8 and 11.3, respectively (Barash 1975, 1974). Mean colony size for Olympic marmots ranged from 7.0 to 10.8 with number of juveniles ranging from 3.0 to 3.9 per colony (Wood 1973). In addition, Holmes (1984) reports an average of 2.8 juveniles per colony from Alaskan hoary marmots and Bryant (1996) counted an average of 3.4 juveniles per colony of Vancouver Island marmots. Smaller composition numbers reported here may be typical in NOCA or it may suggest there were some inconsistencies in the interpretation of discrete colonies, whereas more dispersed marmots that appeared to be of separate colonies perhaps should have been lumped into one family unit. Accurate colony composition would be more achievable through capturing and marking individuals or by more detailed behavioral observations, neither of which were within the scope of this study.

Marmot density is difficult to measure, especially when not all animals at a given site can be enumerated. Distance-based statistical methods may be a possibility worth exploring in the future. These methods develop detection probability as a function of detection distance from the observer to estimate density and variability. Further, it was also acknowledged that topography and trees could change the actual area surveyed, but to discern this and what might be considered unsuitable habitat was deemed beyond the scope of this study. Density estimates from survey sites at NOCA showed considerable variability ranging from 0 to18 marmots per km^2. Similar variability in marmot density was also reported in other studies, ranging from 2 to 15 marmots per km^2 (Jackson 1961, Nowak 1991). Results at NOCA show density of marmots did not always correspond directly with size of survey area. Further, they were often observed colonizing only a small fraction of a meadow in proportion to spatial availability. There were some inconsistencies, whereas smaller areas sometimes supported more marmots per km^2 than larger areas and vice versa. This pattern of variability in density among sites relative to survey area was also noted in a population of yellow-bellied marmots (Ozgul et al. 2006). Area is likely a surrogate for a number of factors, but ultimately tied to resource availability where more resources can support more marmots in a given area. Although we did not directly index site quality, factors known to affect it are timing of snowmelt through its effects on the length of the growing season, plant composition (Van Vuren and Armitage 1991), number of burrows, area, angle of vision, and mean distance to trees (Svedson 1974). It is important to note that NOCA survey area calculations are based on actual area surveyed and not necessarily on habitat area available to marmots at each survey site. This assumption may reflect smaller or more conservative density numbers. More detailed habitat information could be derived from the

LANDSAT data by using more rigorous ArcGIS applications, but was deemed beyond the scope of this initial inventory study.

No overall marmot population estimate in NOCA was attempted. Due to the remote and inaccessible nature of NOCA's subalpine/alpine habitats, only about 9.0% (4,830 ha or 11,935 ac) of the approximate 43,612 ha of the broadly defined suitable marmot habitat was surveyed from this study. Practically all of the easily accessible areas of suitable marmot habitat in the park, areas with trails leading to a meadow, have now been surveyed for marmot presence. Additional survey areas would require extensively more resources in personnel and funding.

Other Considerations

Survey results showed nearly 75% of marmot detections were within 200 m of the observer. Although marmots were detected beyond this distance (up to 434 m), it did become increasingly more challenging to accurately determine age classes the greater the distance. However, this coincided well with point count stations spaced every 400 m, whereas the mid-point was at 200 m, thus maximizing detection and age classification success while minimizing the chance of duplicating counts. Thus, the 400 m spacing between point count stations seems fitting for future marmot monitoring using this type of transect count methodology.

Time spent observing from each point count station was also a factor that began as a guesstimate in the initial sampling design. Surveyors experimented and made adjustments during the first survey and ultimately settled on the 30-minute sampling period. This appears to be an appropriate amount of time to spend at each point count station, based on results showing 80% of marmot detections occurred within the first 20 minutes of the survey.

The sampling time frame of late June to early September proved successful in documenting marmot presence throughout the study area and coincides well to the period of backcountry accessibility in NOCA. This also adheres closely to the sampling time frame recommended for surveying marmots at Olympic National Park (Witczuk 2007). Anecdotal records show adult marmots emerging from their winter burrow during the first week of May with above ground activity reported as late as early October in some areas of NOCA (R. Christophersen, personal observation). However, it's important to note that these late season observations may only include adult females (maternal) and juveniles, and not adult males, as reported by Barash (1976) at Mount Rainier National Park. Late season repeat surveys at Monogram Lake and Twisp Pass sites resulted in no marmots seen on 10 September and 16 September, respectively. These were both areas with marmot presence documented earlier in the summer, suggesting there was seasonal shift in their activity pattern resulting in more time spent in the burrow or they may have already entered into hibernation by mid-September. Marmots were observed on a repeat count of N. Fork Bridge Creek site on 3 September 2008, with one additional marmot counted on the second survey. This was the latest date of marmot presence detected at survey sites during the 2-year study. Marmots may have still been active above ground after this date, but surveys were ended at this point. Because of these seasonal and weather influences a decision was made to terminate surveys in early September, so that presence of all age and gender classes would not be overlooked.

Recommendations

Because this was the first baseline inventory of marmots in NOCA, no information is yet available regarding trends in population levels or persistence of known colonies. Therefore, it is not clear at this time whether the population is stable or unstable. Given the considerable concern about the potential impacts of climate change and increased predation on high elevation species, including marmots, and declines in regional marmot populations, it is recommended that a monitoring program be designed and implemented that would provide information about marmot population trends and status.

There are basically two approaches to the monitoring phase. One alternative would include annual monitoring of a subset of sites surveyed during this study. Annual monitoring would document natural variability in populations and minimize the chance of missing changes in populations in a timely manner. However, this method is likely not sustainable, due to budget constraints.

The second choice would include periodic monitoring (i.e., for 2 years every 10-15 years). This would be the preferred alternative, given it would be more sustainable with current funding opportunities. A presence-absence occupancy method using a subset of sites surveyed from this study is recommended as the basis for the monitoring plan. Although not as statistically robust, this method would be financially and logistically more feasible than more intensive demographic monitoring and could be supported, to some degree, through volunteers with minimal training requirements. In effect, this method focuses on detection of changes in occupancy measured as the proportion of the survey areas where the species is present during the sampling. Findings could then be compared over time and information elucidated that might explain any apparent shifts in occupancy or distribution.

The actual design of the monitoring plan is beyond the scope of this report, but would definitely draw and expound upon the information established from the baseline survey reported herein. It would be most beneficial to continue surveying sites that were surveyed during this 2-year study using similar methods of visual counts during the morning bimodal activity period from late June through early September. Counts should be conducted at the same time each year to minimize variance associated with seasonal pulses of mortality or dispersal. Also, funding may not provide for all 31 of the inventory sites to be sampled during the monitoring phase, but a representative subsample could be selected that includes sites across elevation bands from east, west and mid-divide. In addition, a subsample of sites where marmots were not detected from this study should also be considered in the monitoring plan. This would provide an opportunity to test for possible unoccupied and recolonization events.

Since marmots exhibit a metapopulation structure, it can be expected that some colonies or local networks will vanish over time. A well designed monitoring plan should allow for the detection of collapse of these networks. Based on what was learned about detection probabilities from the inventory work, one visit to each site should be adequate to determine occupancy at most sites. This approach will also be more efficient and cost effective than attempting repeat surveys. However, an approach such as the “removal design” (MacKenzie et al. 2006) could be implemented, whereas a second survey within the season is conducted only at sites where marmots went undetected. Since our detectability rates were quite high, it seems likely that one additional survey would be sufficient for complete removal of the non-detection bias. Ideally, if adequate resources were available, repeat visits could also elucidate more information on abundance variability at sites within and across years. Repeated counts would be useful in determining an index of relative abundance of marmots at survey sites. This information may also be useful in determining how many years of monitoring would be required to detect abundance trends through power analyses.

Monitoring the dynamics of marmot populations in the long-term may provide an indication of other changes in alpine snowpack, plant phenology, and distribution and abundance of predators. Factors affecting marmot populations could then be addressed with future research questions, such as survival rates of adult females or young of the year, dispersal rates and distances, habitat quality and connectivity, and responses to climate change.

Additional research needs may include, (1) the development of a detection model to correct abundance estimates to determine absolute density and, (2) a more robust method to determine habitat use. Model development would require repeat visits to a subset of survey sites. Fine-scale habitat use could be addressed with more detailed vegetation sampling at marmot sightings that are safely accessible. Requirements of additional field personnel and funding are considerations to examine for either of these research endeavors.

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Appendix A. Vegetation classes and class definitions of potential marmot habitat (from Almack et al. 1993, by permission of authors).

1 - Alpine Meadow - East - Herbaceous vegetation is dominant. Composed of alpine meadows usually above 7000 feet. Located on the east side of the ecosystem.

2 - Alpine Meadow - West - Same as above except located on the west side of the ecosystem.

3 - Subalpine Lush Meadow - East - These are located in the subalpine zone and are composed of lush subalpine meadow vegetation on the east side of the ecosystem.

4 - Subalpine Lush Meadow - West - Same as above except located on the west side of the ecosystem.

5 - Subalpine Mesic to Dry Meadow - East - These areas are located in the subalpine zone. These are composed of mesic to dry meadows on the east side of the ecosystem.

6 - Subalpine Mesic to Dry Meadow - West - Same as above except located on the west side of the ecosystem.

7 - Subalpine Meadow with VADE (*Vaccinium deliciosum*) - Subalpine shrubs and meadow with huckleberry.

8 - Subalpine Mosaic - East - A mixture of shrubs, trees, herbs and bare ground with no clear dominant. Located in the subalpine zone on the east side of the ecosystem.

9 - Subalpine Mosaic - West - Same as above except located on the west side of the ecosystem.

10 - Subalpine to Alpine VASC (*Vaccinium caespitosum*), VACA (*Vaccinium scoparium*) - Subalpine shrubs and meadows with huckleberry.

Appendix B. Universal Transverse Mercator (UTM) coordinates of 31survey sites sampled during 2007-2008 marmot surveys in NOCA.

Site No.	Site Name	Date	UTM Easting (NAD 83)	UTM Northing (NAD 83)
24	Monogram Lake	26-Jun-07	626164	5379685
42	Sourdough Mt.	10-Jul-07	638159	5400631
5	Sourdough Lookout	10-Jul-07	640261	5400697
2	Jack Mt. 2	17-Jul-07	648457	5400288
28	Jack Mt 1	18-Jul-07	647297	5399869
20	Desolation Peak	24-Jul-07	645673	5418576
11	South Pass	31-Jul-07	673560	5365596
12	Rainbow Creek	1-Aug-07	668739	5361842
26	Rainbow Ridge	1-Aug-07	671475	5364166
3	Rainbow Lake	2-Aug-07	667337	5364675
27	Purple Pass	9-Aug-07	680609	5353684
31	Twisp Pass	9-Aug-07	674173	5371012
47	Horseshoe Basin	14-Aug-07	646220	5370952
23	Pelton Basin	14-Aug-07	644853	5369845
43	Sahale Arm	15-Aug-07	643868	5370618
8	Park Creek Pass	21-Aug-07	649979	5374720
17	Park Creek Pass South	22-Aug-07	650650	5373230
46	Copper Lookout	28-Aug-07	612912	5418671
35	Copper Ridge	28-Aug-07	609939	5417182
10	Copper Lake	28-Aug-07	613759	5420186
7	Whatcom Pass	30-Aug-07	619342	5414782
19	Goodie Ridge	5-Sep-07	655881	5368472
6	McGregor Mt.	5-Sep-07	661846	5363279
14	Whatcom Pass East	26-Jun-08	620584	5414649
1	Fisher Ck.	9-Jul-08	657622	5381690
30	Lone Mountain	22-Jul-08	678684	5358107
52	Lake Juanita	22-Jul-08	677869	5354433
15	Thornton Lakes	4-Aug-08	623764	5392685
21	Stilleto Peak	12-Aug-08	669995	5371876
51	Fisher Ck. Basin2x	26-Aug-08	658486	5381545
49	North Fork Bridge Ck.2x	3 Sept. 08	653848	5374647

Note 1: Sites are listed in chronological order from the date they were surveyed.
Note 2: 2x indicates second of two surveys for which data was used in final analyses.

Appendix C. Field data form used for inventorying marmots during 2007-2008 marmot surveys in North Cascades National Park Service Complex.

Figure C.1. Field Data Form.

2007-2008 Hoary Marmot Inventory Data Form
North Cascades National Park Service Complex

Page __of __

Site Name____________________________ **Date** ______________ (i.e. 10 July 07)

Site No. ___ ___ **Observer(s)** ______________________

Point of Origin (NAD 83)							
Easting							
Northing							

Site Start Time (in 24 Hr.)	Site End Time (in 24 Hr.)

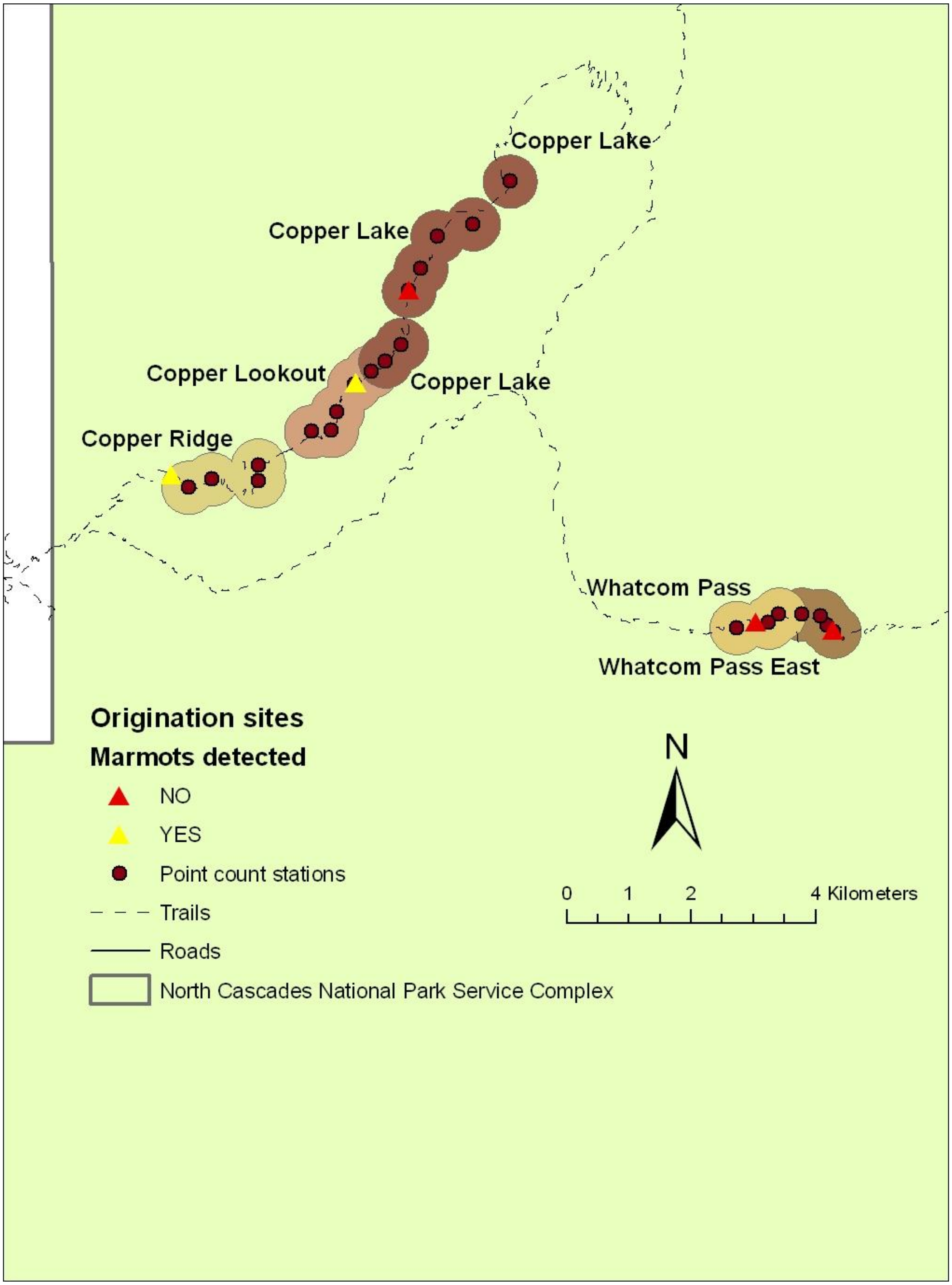
Weather					
Cloud Cover	**Wind**	**Temp.**	**Precip.**	**Noise**	
nearest 10%	L,M,H 0-5,6-10,>10mph	deg. C	none, light rain, rain, thunderstorms, hail, snow	L,M,H	

Point Count No.	**Point Count Start Time (24hr)**	**Elev. at point (ft)**	**UTM at point and accuracy easting (NAD 83)**	**UTM at point and accuracy northing (NAD 83)**	**Detection Time**	**Distance to individual (m)**	**Azimuth to individual**	**Visual or Audio (V or A)**	**Adult or Juvenile (A or J)**	**Slope Aspect**	***Dominant Vegetation Type(s) (25 m radius from animal)**

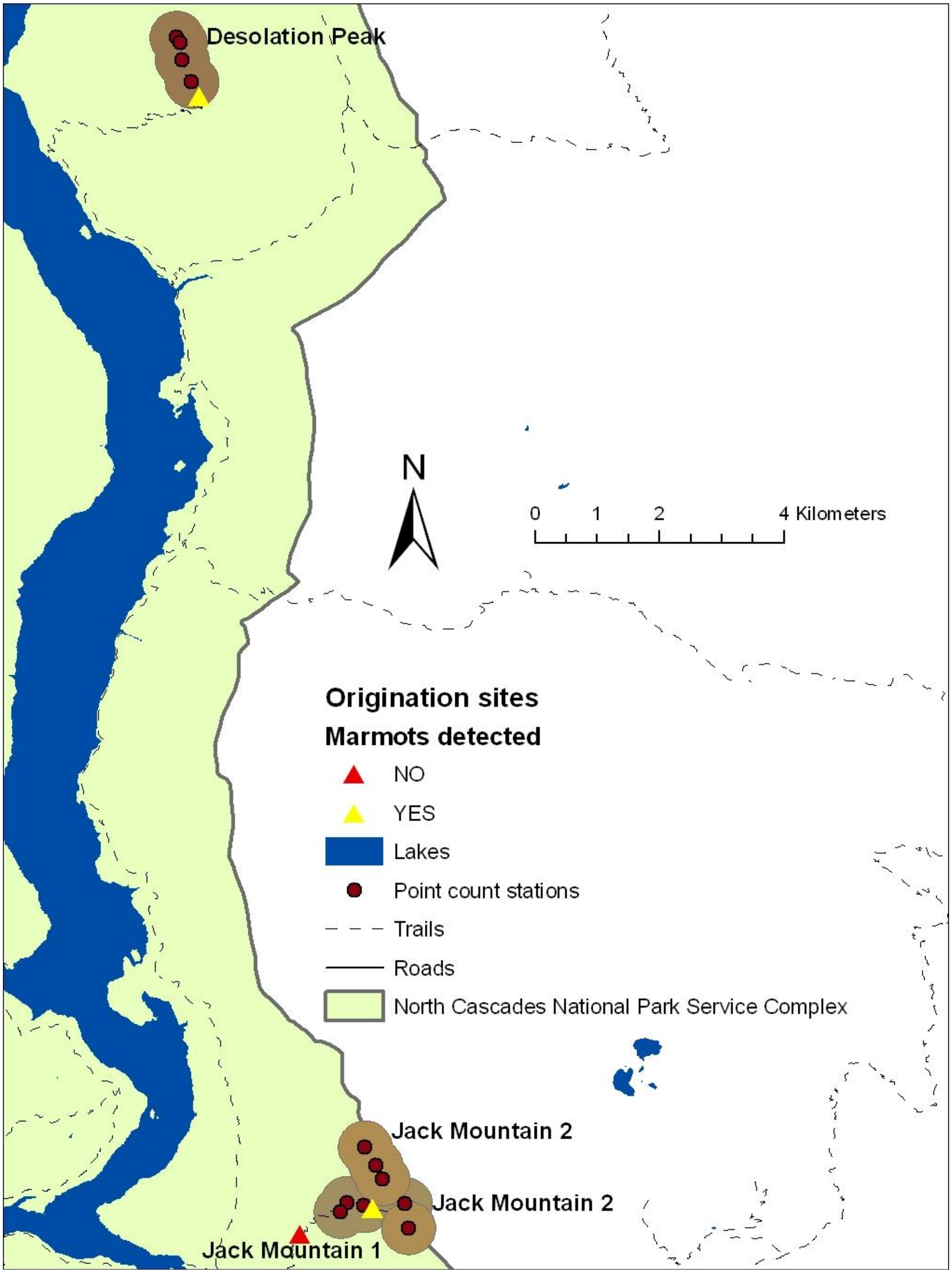
Comments: (i.e., activity of animal, meadow description, waypoint number, burrows present, etc.)

Vegetation Types: 1.) heather; 2.) huckleberry; 3.) sedge/grass; 4.) forb (dominant); 5.) moss; 6.) rock (talus, boulder); 7.) Mtn. ash (shrub); 8.) Mt. hemlock (islands); 9.) subalpine fir; 10.) larch; 11.) whitebark pine

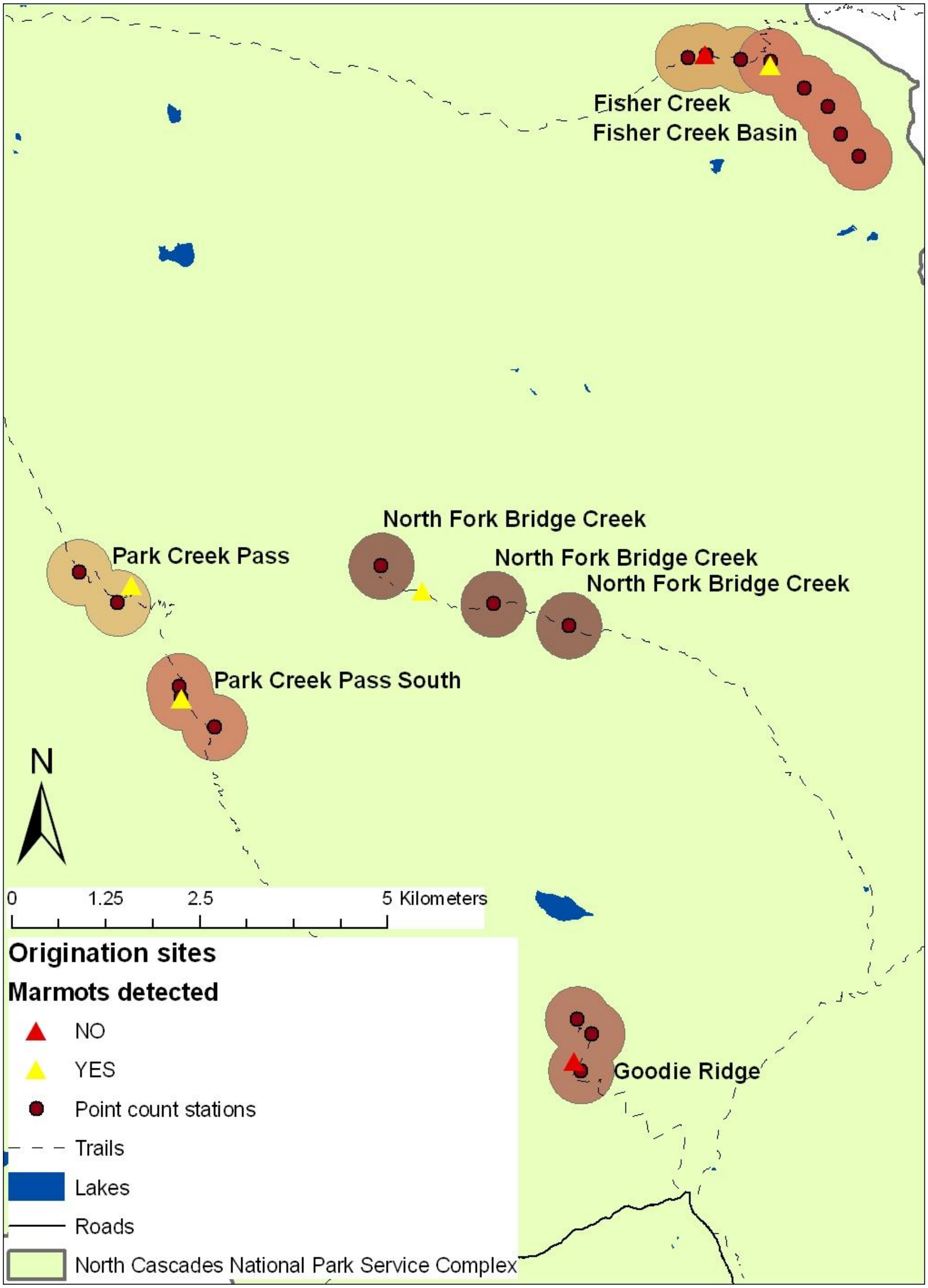
Appendix D. Map of survey sites showing site name, point count stations, area surveyed and occupancy status of each survey site during 2007-2008 marmot surveys in North Cascades National Park Complex.



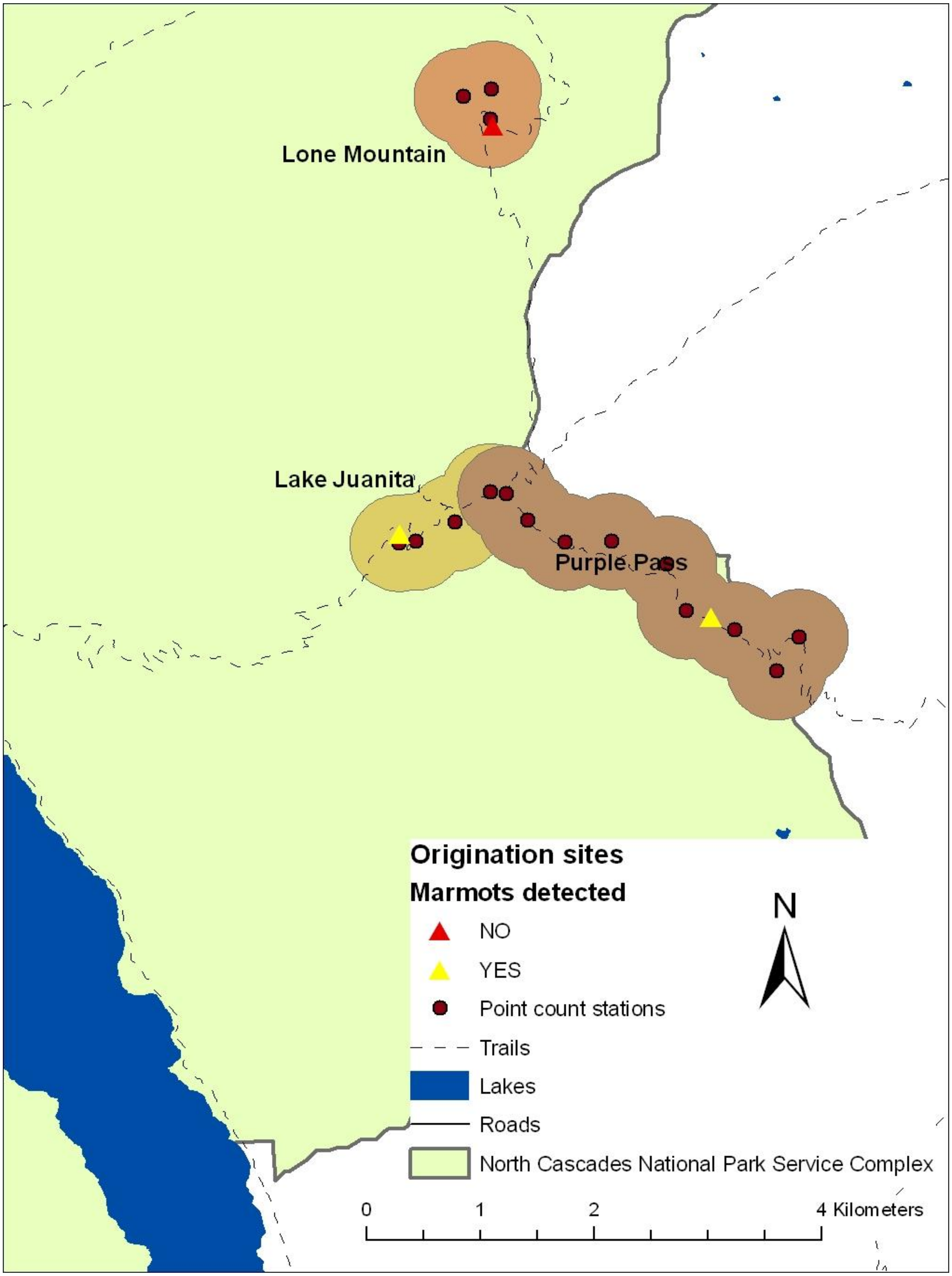
Appendix D. Map of survey sites showing site name, point count stations, area surveyed and occupancy status of each survey site during 2007-2008 marmot surveys in North Cascades National Park Complex (continued).



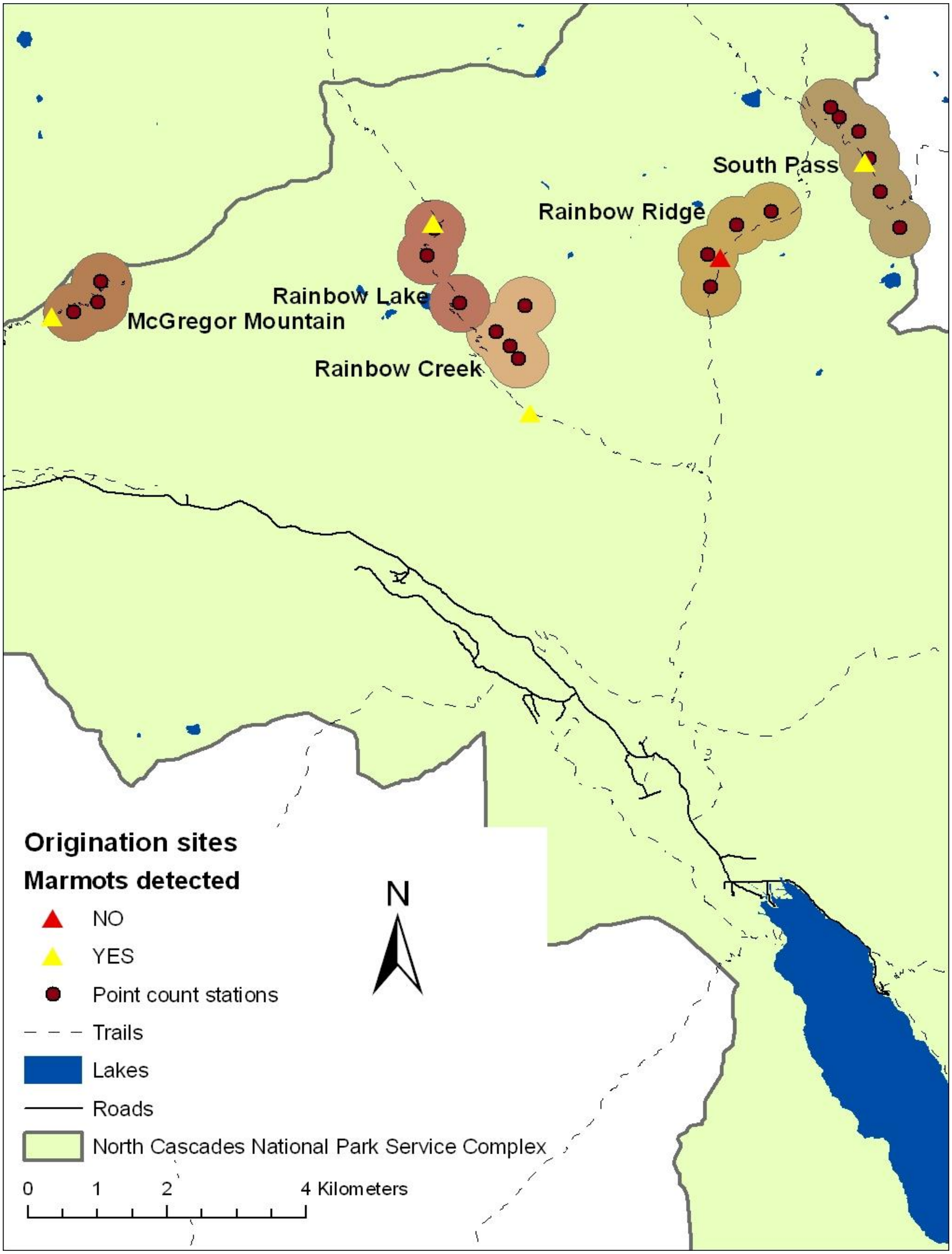
Appendix D. Map of survey sites showing site name, point count stations, area surveyed and occupancy status of each survey site during 2007-2008 marmot surveys in North Cascades National Park Complex (continued).



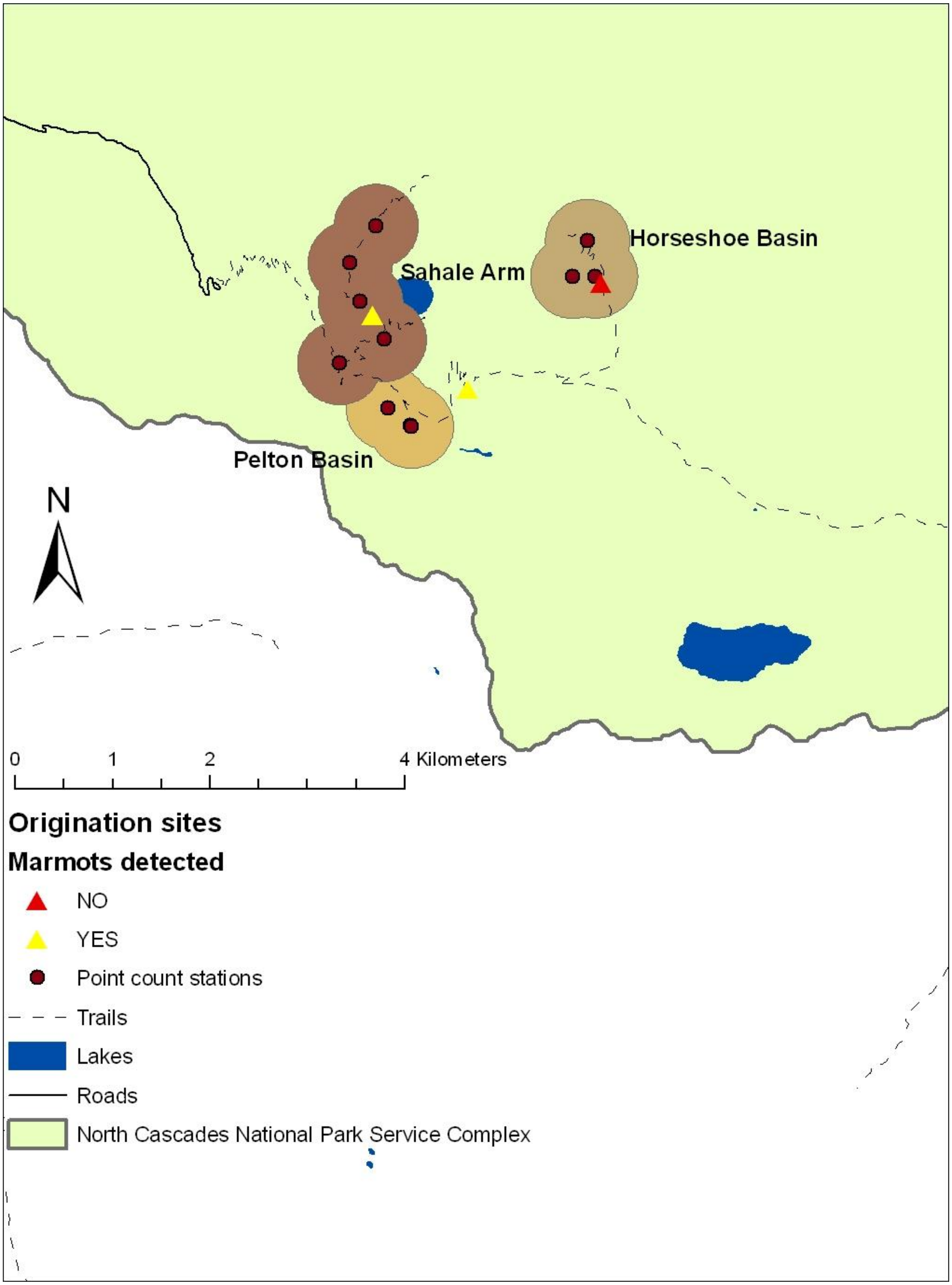
Appendix D. Map of survey sites showing site name, point count stations, area surveyed and occupancy status of each survey site during 2007-2008 marmot surveys in North Cascades National Park Complex (continued).



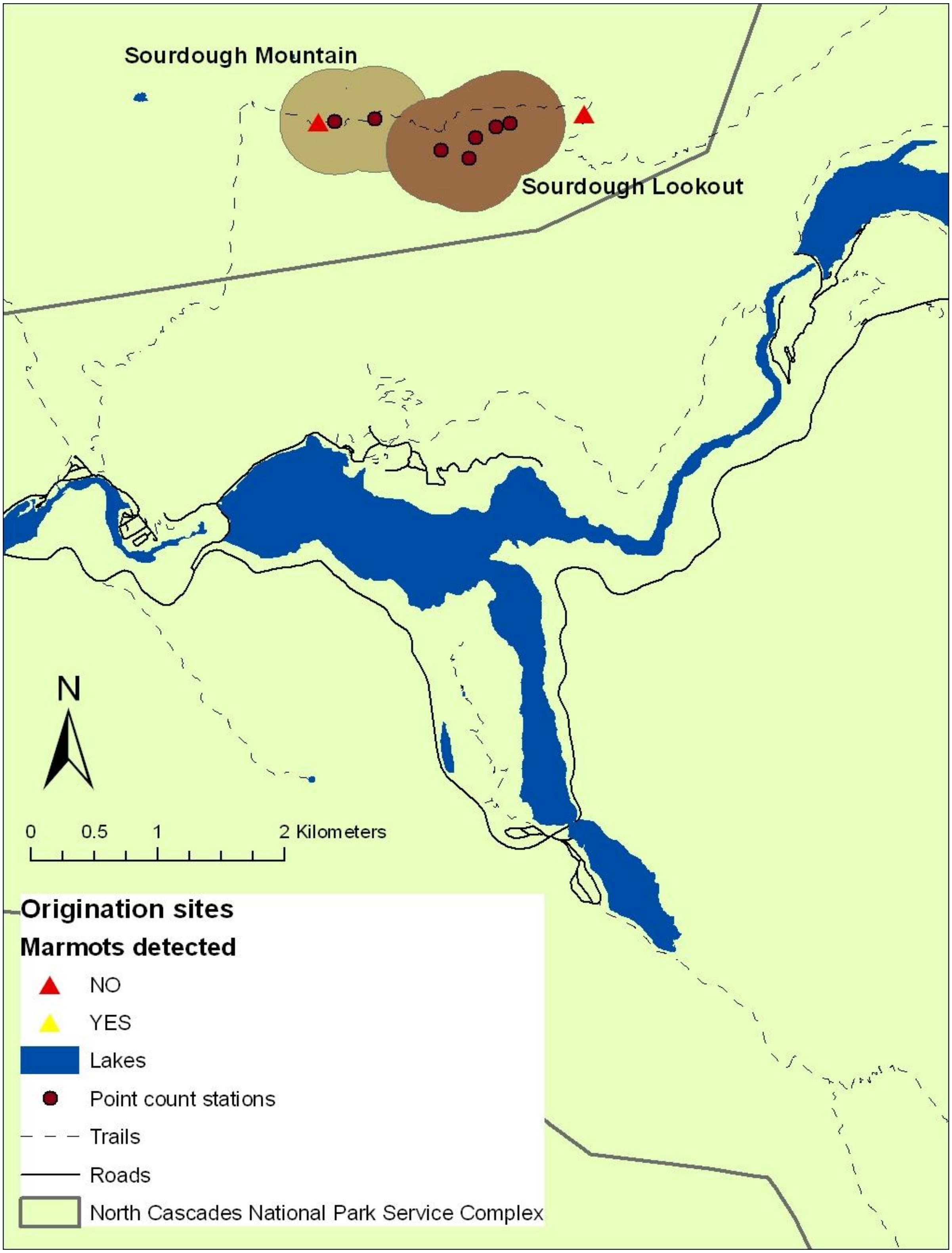
Appendix D. Map of survey sites showing site name, point count stations, area surveyed and occupancy status of each survey site during 2007-2008 marmot surveys in North Cascades National Park Complex (continued).



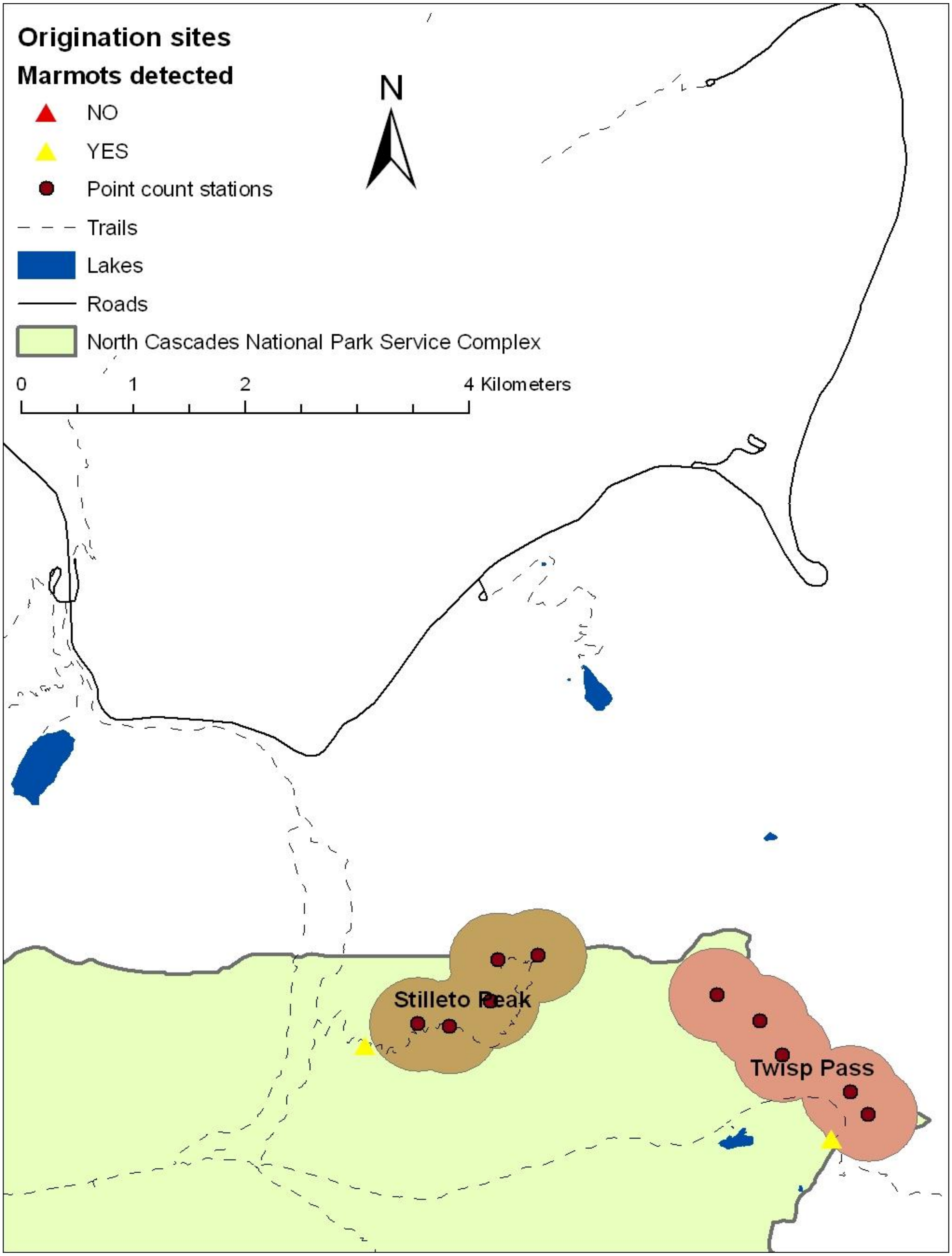
Appendix D. Map of survey sites showing site name, point count stations, area surveyed and occupancy status of each survey site during 2007-2008 marmot surveys in North Cascades National Park Complex (continued).



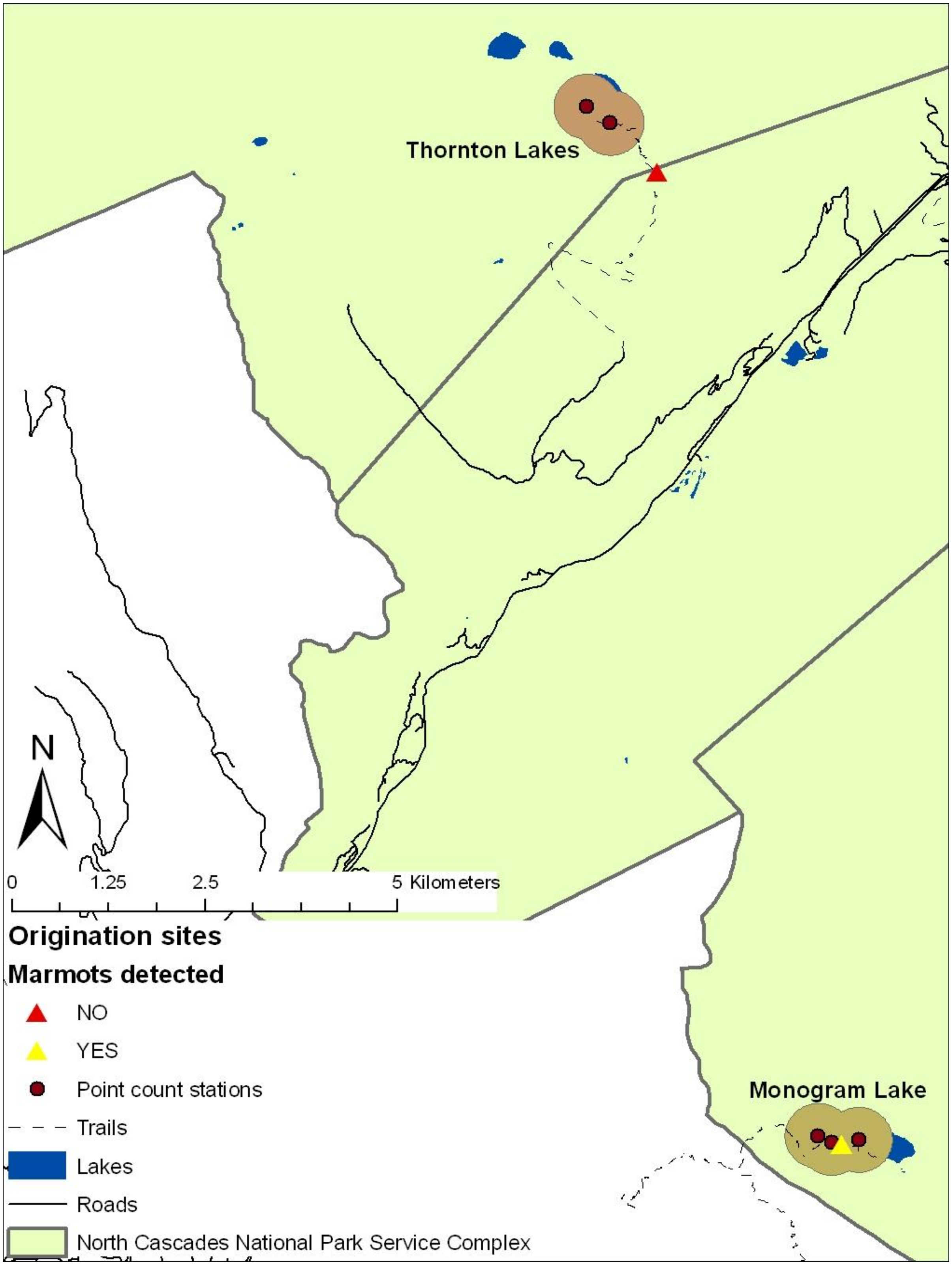
Appendix D. Map of survey sites showing site name, point count stations, area surveyed and occupancy status of each survey site during 2007-2008 marmot surveys in North Cascades National Park Complex (continued).



Appendix D. Map of survey sites showing site name, point count stations, area surveyed and occupancy status of each survey site during 2007-2008 marmot surveys in North Cascades National Park Complex (continued).



Appendix D. Map of survey sites showing site name, point count stations, area surveyed and occupancy status of each survey site during 2007-2008 marmot surveys in North Cascades National Park Complex (continued).



Appendix E. Sampling data collected during 2007-2008 marmot surveys in NOCA.

Site Name	Date	Point Count	Point Start Time	Elev Point (m)	UTM_x Point NAD 83)	UTM_y Point (NAD 83)	Detection Time	Distance to Marmot (m)	Azimuth	Audio/Visual	Age	Aspect	[1]Dominant Veg Type
Monogram Lake	26-Jun-07	1	6:30	1634	626023	5379706	6:30	125	70	V	A	S	4
Monogram Lake	26-Jun-07	1	6:30	1634	626023	5379706	6:30	147	338	V	A	S	4
Monogram Lake	26-Jun-07	2	9:16	1652	626377	5379746	9:16	400	270	V	A	SE	6
Monogram Lake	26-Jun-07	2	9:16	1652	626377	5379746	9:46	253	204	V	A	SE	4
Monogram Lake	26-Jun-07	2	9:16	1652	626377	5379746	9:48	304	291	V	A	SE	4
Monogram Lake	26-Jun-07	2	9:16	1652	626377	5379746	9:49	246	308	V	A	SE	4
Monogram Lake	26-Jun-07	2	9:16	1652	626377	5379746	10:04	281	392	V	A	SE	6
Monogram Lake	26-Jun-07	2	9:16	1652	626377	5379746	10:12	271	306	V	A	SE	4
Monogram Lake	26-Jun-07	2	9:16	1652	626377	5379746	10:19	271	306	V	A	SE	4
Monogram Lake	26-Jun-07	3	11:58	1698	625851	5379798	11:00	201	2	V	A	SW	2
Monogram Lake	26-Jun-07	3	11:58	1698	625851	5379798	11:01	201	2	V	A	SW	2
Sourdough MT.	10-Jul-07	1	10:20	1695	638600	5400652	NA	NA	NA	NA	NA	NA	NA
Sourdough MT.	10-Jul-07	2	11:05	1618	638284	5400634	NA	NA	NA	NA	NA	NA	NA
Sourdough Lookout	10-Jul-07	1	8:20	1594	639668	5400618	NA	NA	NA	NA	NA	NA	NA
Sourdough Lookout	10-Jul-07	2	9:24	1594	639559	5400586	NA	NA	NA	NA	NA	NA	NA
Sourdough Lookout	10-Jul-07	3	10:03	1634	639399	5400496	NA	NA	NA	NA	NA	NA	NA
Sourdough Lookout	10-Jul-07	4	10:48	1686	639346	5400327	NA	NA	NA	NA	NA	NA	NA
Sourdough Lookout	10-Jul-07	5	11:30	1728	639124	5400399	NA	NA	NA	NA	NA	NA	NA
Jack Mt. 2	17-Jul-07	1	6:48	1832	649030	5399960	6:49	163	26	V	A	SE	6
Jack Mt. 2	17-Jul-07	1	6:48	1832	649030	5399960	6:49	162	26	V	A	SE	6
Jack Mt. 2	17-Jul-07	1	6:48	1832	649030	5399960	6:49	164	26	V	J	SE	6
Jack Mt. 2	17-Jul-07	1	6:48	1832	649030	5399960	6:49	160	26	V	J	SE	6
Jack Mt. 2	17-Jul-07	1	6:48	1832	649030	5399960	7:10	345	354	V	A	SE	4
Jack Mt. 2	17-Jul-07	1	6:48	1832	649030	5399960	7:10	348	354	V	A	SE	4
Jack Mt. 2	17-Jul-07	1	6:48	1832	649030	5399960	7:11	163	26	V	Y	SE	6
Jack Mt. 2	17-Jul-07	2	8:06	2006	648615	5400764	8:07	167	100	V	A	S	6
Jack Mt. 2	17-Jul-07	2	8:06	2006	648615	5400764	8:07	167	100	V	A	S	6
Jack Mt. 2	17-Jul-07	2	8:06	2006	648615	5400764	8:07	167	100	V	Y	S	6
Jack Mt. 2	17-Jul-07	2	8:06	2006	648615	5400764	8:07	167	100	V	Y	S	6
Jack Mt. 2	17-Jul-07	2	8:06	2006	648615	5400764	8:07	167	100	V	Y	S	6
Jack Mt. 2	17-Jul-07	3	10:24	2051	648507	5400982	10:25	194	308	V	A	SE	1
Jack Mt. 2	17-Jul-07	4	11:28	2030	648333	5401290	11:46	430	64	V	A	SE	6
Jack Mt. 2	17-Jul-07	4	11:28	2030	648333	5401290	11:46	434	64	V	A	SE	6
Jack Mt. 2	17-Jul-07	4	11:28	2030	648333	5401290	11:46	432	64	V	A	SE	6
Jack Mt 1	18-Jul-07	1	7:26	1821	648316	5400322	NA	NA	NA	NA	NA	NA	NA
Jack Mt 1	18-Jul-07	2	7:41	1777	648979	5400357	NA	NA	NA	NA	NA	NA	NA
Jack Mt 1	18-Jul-07	3	8:30	1750	648042	5400375	NA	NA	NA	NA	NA	NA	NA
Jack Mt 1	18-Jul-07	4	9:50	1686	647943	5400228	NA	NA	NA	NA	NA	NA	NA
Desolation Peak	24-Jul-07	1	9:45	1823	645302	5419553	9:46	25	180	V	A	S	6
Desolation Peak	24-Jul-07	2	10:38	1850	645358	5419460	10:44	218	180	V	A	E	6
Desolation Peak	24-Jul-07	2	10:38	1850	645358	5419460	10:45	167	164	V	A	E	6

[1]**Vegetation Types:** 1). heather; 2). huckleberry; 3). sedge/grass; 4). forb (dominant); 5.) moss; 6). talus/boulder); 7). Mtn. ash (shrub); 8). Mt. hemlock (islands); 9.) subalpine fir; 10.) larch; 11.) whitebark pine
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Appendix E. Data collected during 2007-2008 marmot surveys in NOCA (continued).

Site Name	Date	Point Count	Point Start Time	Elev Point (m)	UTM_x Point NAD 83)	UTM_y Point (NAD 83)	Detection Time	Distance to Marmot (m)	Azimuth	Audio/Visual	Age	Aspect	[1]Dominant Veg Type
Desolation Peak	24-Jul-07	2	10:38	1850	645358	5419460	10:46	158	172	V	Y	E	6
Desolation Peak	24-Jul-07	2	10:38	1850	645358	5419460	10:46	150	164	V	Y	E	6
Desolation Peak	24-Jul-07	2	10:38	1850	645358	5419460	10:52	208	82	V	A	E	6
Desolation Peak	24-Jul-07	2	10:38	1850	645358	5419460	11:04	198	180	V	J	E	6
Desolation Peak	24-Jul-07	3	11:18	1545	645388	5419182	11:20	360	248	V	A	NW	4
Desolation Peak	24-Jul-07	3	11:18	1545	645388	5419182	11:27	105	40	V	Y	SE	6
Desolation Peak	24-Jul-07	3	11:18	1545	645388	5419182	11:27	105	40	V	Y	SE	6
Desolation Peak	24-Jul-07	3	11:18	1545	645388	5419182	11:28	105	40	V	J	SE	6
Desolation Peak	24-Jul-07	4	14:20	1725	645545	5418822	14:47	132	54	V	A	SE	6
South Pass	31-Jul-07	1	7:02	1856	673177	5366260	7:10	84	350	V	A	SW	2
South Pass	31-Jul-07	1	7:02	1856	673177	5366260	7:10	69	10	V	Y	SW	2
South Pass	31-Jul-07	1	7:02	1856	673177	5366260	7:26	160	204	A	unk	W	10
South Pass	31-Jul-07	1	7:02	1856	673177	5366260	7:30	38	288	V	A	SW	2
South Pass	31-Jul-07	2	8:10	1856	673058	5366410	8:15	45	310	V	J	SW	6
South Pass	31-Jul-07	2	8:10	1856	673058	5366410	8:16	40	250	V	J	SW	6
South Pass	31-Jul-07	2	8:10	1856	673058	5366410	8:16	45	310	V	A	SW	6
South Pass	31-Jul-07	2	8:10	1856	673058	5366410	8:16	45	310	V	A	SW	6
South Pass	31-Jul-07	2	8:10	1856	673058	5366410	8:16	45	310	V	Y	SW	6
South Pass	31-Jul-07	2	8:10	1856	673058	5366410	8:16	45	310	V	Y	SW	6
South Pass	31-Jul-07	3	9:52	1939	673467	5366044	9:54	67	40	V	A	W	6
South Pass	31-Jul-07	3	9:52	1939	673467	5366044	9:54	67	40	V	Y	W	6
South Pass	31-Jul-07	3	9:52	1939	673467	5366044	9:54	67	40	V	Y	W	6
South Pass	31-Jul-07	3	9:52	1939	673467	5366044	1012	210	38	V	A	SW	2
South Pass	31-Jul-07	3	9:52	1939	673467	5366044	1015	287	18	V	A	SW	6
South Pass	31-Jul-07	3	9:52	1939	673467	5366044	1015	287	18	V	A	SW	6
South Pass	31-Jul-07	3	9:52	1939	673467	5366044	1019	62	130	V	A	W	2
South Pass	31-Jul-07	4	10:35	1908	673611	5365643	1035	NA	NA	NA	NA	NA	NA
South Pass	31-Jul-07	5	11:18	1859	673776	5365148	NA	NA	NA	NA	NA	NA	NA
South Pass	31-Jul-07	6	11:56	1865	674048	5364607	1157	26	132	V	A	W	6
Rainbow Creek	1-Aug-07	1	8:45	1576	668654	5363447	NA	NA	NA	NA	NA	NA	NA
Rainbow Creek	1-Aug-07	2	9:31	1631	668560	5362650	932	18	258	V	A	W	6
Rainbow Creek	1-Aug-07	2	9:31	1631	668560	5362650	932	18	258	V	A	W	6
Rainbow Creek	1-Aug-07	3	10:38	1676	668441	5362835	1039	210	20	V	A	W	6
Rainbow Creek	1-Aug-07	3	10:38	1676	668441	5362835	1039	210	20	V	A	W	6
Rainbow Creek	1-Aug-07	3	10:38	1676	668441	5362835	1039	210	20	V	A	W	6
Rainbow Creek	1-Aug-07	3	10:38	1676	668441	5362835	1040	262	24	V	A	W	6
Rainbow Creek	1-Aug-07	3	10:38	1676	668441	5362835	1040	247	32	V	A	W	6
Rainbow Creek	1-Aug-07	4	11:20	1689	668241	5363059	1125	72	10	V	A	W	6
Rainbow Creek	1-Aug-07	4	11:20	1689	668241	5363059	1125	72	10	V	Y	W	6
Rainbow Ridge	1-Aug-07	1	7:40	1529	672195	5364858	NA	NA	NA	NA	NA	NA	NA

[1]**Vegetation Types:** 1). heather; 2). huckleberry; 3). sedge/grass; 4). forb (dominant); 5.) moss; 6). talus/boulder; 7). Mtn. ash (shrub); 8). Mt. hemlock (islands); 9.) subalpine fir; 10.) larch; 11.) whitebark pine
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Appendix E. Data collected during 2007-2008 marmot surveys in NOCA (continued).

Site Name	Date	Point Count	Point Start Time	Elev Point (m)	UTM_x Point NAD 83)	UTM_y Point (NAD 83)	Detection Time	Distance to Marmot (m)	Azimuth	Audio/Visual	Age	Aspect	[1]Dominant Veg Type
Rainbow Ridge	1-Aug-07	2	8:40	1575	671703	5364650	NA	NA	NA	NA	NA	NA	NA
Rainbow Ridge	1-Aug-07	3	9:50	1527	671287	5364214	NA	NA	NA	NA	NA	NA	NA
Rainbow Ridge	1-Aug-07	4	11:05	1487	671328	5363721	NA	NA	NA	NA	NA	NA	NA
Rainbow Lake	2-Aug-07	1	7:00	1713	667710	5363485	702	17	38	V	A	W	6
Rainbow Lake	2-Aug-07	1	7:00	1713	667710	5363485	702	15	40	V	J	W	6
Rainbow Lake	2-Aug-07	1	7:00	1713	667710	5363485	702	15	40	V	J	W	6
Rainbow Lake	2-Aug-07	1	7:00	1713	667710	5363485	702	20	32	V	A	W	6
Rainbow Lake	2-Aug-07	2	7:40	1786	667248	5364197	740	270	200	V	A	NW	4
Rainbow Lake	2-Aug-07	2	7:40	1786	667248	5364197	742	300	200	V	A	NW	4
Rainbow Lake	2-Aug-07	2	7:40	1786	667248	5364197	742	300	200	V	A	NW	4
Rainbow Lake	2-Aug-07	2	7:40	1786	667248	5364197	745	285	200	V	J	NW	4
Rainbow Lake	2-Aug-07	2	7:40	1786	667248	5364197	745	285	200	V	J	NW	4
Rainbow Lake	2-Aug-07	3	8:21	1786	667355	5364593	822	145	210	V	A	NW	6
Rainbow Lake	2-Aug-07	3	8:21	1786	667355	5364593	834	168	220	V	A	NW	6
Purple Pass	9-Aug-07	1	7:03	2198	681380	5353502	NA	NA	NA	NA	NA	NA	NA
Purple Pass	9-Aug-07	2	7:40	2100	681183	5353196	741	180	74	A	unk	NW	6
Purple Pass	9-Aug-07	2	7:40	2100	681183	5353196	742	176	94	A	unk	NW	6
Purple Pass	9-Aug-07	2	7:40	2100	681183	5353196	743	127	128	A	unk	NW	6
Purple Pass	9-Aug-07	2	7:40	2100	681183	5353196	744	126	152	A	unk	NW	6
Purple Pass	9-Aug-07	2	7:40	2100	681183	5353196	745	187	162	A	unk	NW	6
Purple Pass	9-Aug-07	2	7:40	2100	681183	5353196	746	222	206	A	unk	NW	6
Purple Pass	9-Aug-07	2	7:40	2100	681183	5353196	746	222	206	A	unk	NW	6
Purple Pass	9-Aug-07	3	8:02	2079	680814	5353568	NA	NA	NA	NA	NA	NA	NA
Purple Pass	9-Aug-07	4	8:42	2033	680387	5353744	NA	NA	NA	NA	NA	NA	NA
Purple Pass	9-Aug-07	5	9:23	2036	680220	5354161	925	67	24	V	A	SW	6
Purple Pass	9-Aug-07	5	9:23	2036	680220	5354161	930	132	98	V	A	SW	6
Purple Pass	9-Aug-07	5	9:23	2036	680220	5354161	931	172	72	V	A	SW	6
Purple Pass	9-Aug-07	5	9:23	2036	680220	5354161	931	168	86	V	A	SW	6
Purple Pass	9-Aug-07	5	9:23	2036	680220	5354161	941	246	102	V	A	SW	6
Purple Pass	9-Aug-07	5	9:23	2036	680220	5354161	942	62	112	A	unk	SW	6
Purple Pass	9-Aug-07	5	9:23	2036	680220	5354161	943	56	98	V	J	SW	6
Purple Pass	9-Aug-07	6	10:06	2045	679731	5354365	1008	138	118	V	A	S	4
Purple Pass	9-Aug-07	6	10:06	2045	679731	5354365	1013	226	142	V	A	SW	4
Purple Pass	9-Aug-07	7	10:45	2067	679317	5354361	NA	NA	NA	NA	NA	NA	NA
Purple Pass	9-Aug-07	8	11:23	2036	678990	5354557	1125	68	118	V	A	S	6
Purple Pass	9-Aug-07	8	11:23	2036	678990	5354557	1126	74	118	"	A	S	6
Purple Pass	9-Aug-07	8	11:23	2036	678990	5354557	1140	40	90	A	unk	S	6
Purple Pass	9-Aug-07	8	11:23	2036	678990	5354557	1140	218	102	A	unk	S	6

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Appendix E. Data collected during 2007-2008 marmot surveys in NOCA (continued).

Site Name	Date	Point Count	Point Start Time	Elev Point (m)	UTM_x Point NAD 83)	UTM_y Point (NAD 83)	Detection Time	Distance to Marmot (m)	Azimuth	Audio/Visual	Age	Aspect	[1]Dominant Veg Type
Purple Pass	9-Aug-07	9	11:53	2033	678805	5354793	1153	58	220	V	A	S	4
Purple Pass	9-Aug-07	9	11:53	2033	678805	5354793	1153	64	340	V	A	W	6
Purple Pass	9-Aug-07	9	11:53	2033	678805	5354793	1155	108	294	V	A	S	4
Purple Pass	9-Aug-07	9	11:53	2033	678805	5354793	1155	108	294	V	A	S	4
Twisp Pass	9-Aug-07	1	7:20	2065	673142	5372346	725	110	236	V	A	SE	6
Twisp Pass	9-Aug-07	1	7:20	2065	673142	5372346	728	200	222	V	A	SE	6
Twisp Pass	9-Aug-07	1	7:20	2065	673142	5372346	748	158	220	V	A	E	6
Twisp Pass	9-Aug-07	1	7:20	2065	673142	5372346	758	25	20	V	A	SE	4
Twisp Pass	9-Aug-07	2	8:30	2009	673523	5372098	846	400	28	V	A	SE	6
Twisp Pass	9-Aug-07	2	8:30	2009	673523	5372098	853	400	28	V	A	SE	6
Twisp Pass	9-Aug-07	2	8:30	2009	673523	5372098	900	200	28	A	unk	SE	6
Twisp Pass	9-Aug-07	3	9:30	1945	673728	5371787	NA	NA	NA	NA	NA	NA	NA
Twisp Pass	9-Aug-07	4	10:30	1905	674334	5371440	NA	NA	NA	NA	NA	NA	NA
Twisp Pass	9-Aug-07	5	11:20	1887	674499	5371238	NA	NA	NA	NA	NA	NA	NA
Horseshoe Basin	14-Aug-07	1	7:35	1353	646073	5371392	NA	NA	NA	NA	NA	NA	NA
Horseshoe Basin	14-Aug-07	2	8:16	1362	645922	5371020	NA	NA	NA	NA	NA	NA	NA
Horseshoe Basin	14-Aug-07	3	9:10	1268	646156	5371024	NA	NA	NA	NA	NA	NA	NA
Pelton Basin	14-Aug-07	1	16:43	1433	644026	5369647	17:01	149	294	V	A	NE	6
Pelton Basin	14-Aug-07	2	17:31	1396	644256	5369464	17:31	69	56	V	Y	E	6
Pelton Basin	14-Aug-07	2	17:31	1396	644256	5369464	17:32	65	190	V	Y	E	6
Pelton Basin	14-Aug-07	2	17:31	1396	644256	5369464	17:33	63	124	V	A	E	6
Pelton Basin	14-Aug-07	2	17:31	1396	644256	5369464	17:34	73	104	V	A	E	6
Pelton Basin	14-Aug-07	2	17:31	1396	644256	5369464	17:37	69	196	V	A	E	6
Pelton Basin	14-Aug-07	2	17:31	1396	644256	5369464	17:44	73	182	V	A	E	4
Pelton Basin	14-Aug-07	2	17:31	1396	644256	5369464	17:44	70	182	V	J	E	4
Pelton Basin	14-Aug-07	2	17:31	1396	644256	5369464	17:48	200	152	V	Y	NE	6
Pelton Basin	14-Aug-07	2	17:31	1396	644256	5369464	17:48	200	152	V	A	NE	6
Pelton Basin	14-Aug-07	2	17:31	1396	644256	5369464	17:53	67	164	V	Y	E	6
Pelton Basin	14-Aug-07	3	18:16	1381	644262	5369457	18:20	325	112	V	unk	N	6
Pelton Basin	14-Aug-07	3	18:16	1381	644262	5369457	18:35	299	194	A	unk	N	6
Pelton Basin	14-Aug-07	3	18:16	1381	644262	5369457	18:36	259	220	A	unk	N	6
Pelton Basin	14-Aug-07	3	18:16	1381	644262	5369457	18:37	196	82	A	unk	N	6
Sahale Arm	15-Aug-07	1	6:48	1609	643524	5370119	649	115	88	V	A	S	6
Sahale Arm	15-Aug-07	1	6:48	1609	643524	5370119	649	115	88	V	A	S	6
Sahale Arm	15-Aug-07	1	6:48	1609	643524	5370119	649	115	88	V	J	S	6
Sahale Arm	15-Aug-07	1	6:48	1609	643524	5370119	649	115	88	V	Y	S	6
Sahale Arm	15-Aug-07	2	8:02	1762	647773	5370346	803	188	232	V	A	S	4
Sahale Arm	15-Aug-07	2	8:02	1762	647773	5370346	807	92	322	V	A	S	4
Sahale Arm	15-Aug-07	2	8:02	1762	647773	5370346	809	106	190	V	J	S	4
Sahale Arm	15-Aug-07	2	8:02	1762	647773	5370346	809	106	190	V	A	S	4

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Sahale Arm	15-Aug-07	2	8:02	1762	647773	5370346	809	110	190	V	Y	S	4
Sahale Arm	15-Aug-07	2	8:02	1762	647773	5370346	822	22	228	V	Y	S	6
Sahale Arm	15-Aug-07	2	8:02	1762	647773	5370346	808	20	320	V	A	S	4
Sahale Arm	15-Aug-07	2	8:02	1762	647773	5370346	812	10	86	V	A	SW	6
Sahale Arm	15-Aug-07	3	9:11	1838	643739	5370758	913	244	136	V	A	NE	4
Sahale Arm	15-Aug-07	3	9:11	1838	643739	5370758	914	211	352	A	unk	S	4
Sahale Arm	15-Aug-07	3	9:11	1838	643739	5370758	915	406	20	V	unk	SE	4
Sahale Arm	15-Aug-07	4	10:15	1939	643634	5371163	10:16	145	356	V	A	NE	1
Sahale Arm	15-Aug-07	4	10:15	1939	643634	5371163	10:17	140	198	V	Y	E	1
Sahale Arm	15-Aug-07	5	10:57	1987	643901	5371550	11:18	150	350	V	A	W	6
Sahale Arm	15-Aug-07	5	10:57	1987	643901	5371550	11:20	183	40	V	A	SE	1
Park Creek Pass	21-Aug-07	1	10:05	1375	649276	5374887	10:05	70	292	V	Y	NW	6
Park Creek Pass	21-Aug-07	1	10:05	1375	649276	5374887	10:06	100	306	V	A	NW	6
Park Creek Pass	21-Aug-07	1	10:05	1375	649276	5374887	10:07	70	308	V	A	NW	6
Park Creek Pass	21-Aug-07	1	10:05	1375	649276	5374887	10:29	20	292	V	J	NW	4
Park Creek Pass	21-Aug-07	1	10:05	1375	649276	5374887	10:38	165	228	V	unk	E	7
Park Creek Pass	21-Aug-07	2	10:46	1506	649789	5374486	11:47	286	64	V	A	SW	6
Park Creek Pass	21-Aug-07	2	10:46	1506	649789	5374486	11:50	8	58	V	A	NE	6
Park Creek Pass	21-Aug-07	2	10:46	1506	649789	5374486	11:56	90	142	V	A	N	6
Park Creek Pass	21-Aug-07	2	10:4	1506	649789	5374486	11:56	90	142	V	A	N	6
Park Creek Pass South	22-Aug-07	1	8:37	1737	650609	5373389	838	100	360	A	unk	S	6
Park Creek Pass South	22-Aug-07	1	8:37	1737	650609	5373389	855	122	80	V	A	S	6
Park Creek Pass South	22-Aug-07	1	8:37	1737	650609	5373389	857	74	242	V	A	S	2
Park Creek Pass South	22-Aug-07	1	8:37	1737	650609	5373389	906	86	122	V	unk	S	6
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	942	149	58	V	A	S	6
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	943	149	58	V	A	S	6
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	943	144	58	V	Y	S	6
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	945	176	70	V	A	S	6
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	946	169	86	V	A	S	6
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	947	169	86	V	A	S	6
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	947	169	86	V	J	S	6
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	947	200	115	V	A	S	4
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	1008	130	140	V	Y	S	4
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	1010	64	98	V	Y	S	4
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	1010	62	98	V	J	S	4
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	1010	242	126	V	A	S	6
Park Creek Pass South	22-Aug-07	2	9:41	1698	650636	5373247	1010	82	20	A	unk	S	6
Park Creek Pass South	22-Aug-07	3	11:02	1689	651078	5372852	1104	371	288	V	J	S	6
Park Creek Pass South	22-Aug-07	3	11:02	1689	651078	5372852	1104	375	290	A	unk	S	6
Park Creek Pass South	22-Aug-07	3	11:02	1689	651078	5372852	1128	229	190	V	A	S	6

[1]**Vegetation Types:** 1). heather; 2). huckleberry; 3). sedge/grass; 4). forb (dominant); 5.) moss; 6). talus/boulder; 7). Mtn. ash (shrub); 8). Mt. hemlock (islands); 9.) subalpine fir; 10.) larch; 11.) whitebark pine
Note 1: NA means "not applicable" when no marmots were detected at the point count station.
Note 2: 2x after site name indicates site was surveyed twice with the greater of the two count numbers recorded here.

Appendix E. Data collected during 2007-2008 marmot surveys in NOCA (continued).

Site Name	Date	Point Count	Point Start Time	Elev Point (m)	UTM_x Point NAD 83)	UTM_y Point (NAD 83)	Detection Time	Distance to Marmot (m)	Azimuth	Audio/Visual	Age	Aspect	[1]Dominant Veg Type
Park Creek Pass South	22-Aug-07	3	11:02	1689	651078	5372852	1129	386	284	V	A	S	6
Park Creek Pass South	22-Aug-07	3	11:02	1689	651078	5372852	1129	52	350	V	A	S	6
Copper Lookout	28-Aug-07	1	8:30	1829	613153	5418861	NA	NA	NA	NA	NA	NA	NA
Copper Lookout	28-Aug-07	2	9:30	1843	612878	5418646	930	102	296	V	A	NW	6
Copper Lookout	28-Aug-07	2	9:30	1843	612878	5418646	930	102	296	V	A	NW	6
Copper Lookout	28-Aug-07	2	9:30	1843	612878	5418646	930	102	296	V	J	NW	6
Copper Lookout	28-Aug-07	2	9:30	1843	612878	5418646	930	102	296	V	J	NW	6
Copper Lookout	28-Aug-07	2	9:30	1843	612878	5418646	930	102	296	V	J	NW	6
Copper Lookout	28-Aug-07	2	9:30	1843	612878	5418646	10:00	113	184	V	A	SE	1
Copper Lookout	28-Aug-07	2	9:30	1843	612878	5418646	10:00	113	184	A	unk	SE	1
Copper Lookout	28-Aug-07	3	10:30	1828	612600	5418203	10:50	159	308	V	A	W	6
Copper Lookout	28-Aug-07	4	11:30	1793	612505	5417890	11:35	200	360	A	unk	SW	6
Copper Lookout	28-Aug-07	5	12:10	1667	612181	5417877	NA	NA	NA	NA	NA	NA	NA
Copper Ridge	28-Aug-07	1	7:11	1695	610209	5416965	736	295	334	V	unk	SE	7
Copper Ridge	28-Aug-07	2	8:13	1647	610581	5417098	818	424	288	A	A	S	6
Copper Ridge	28-Aug-07	2	8:13	1647	610581	5417098	837	424	288	V	J	S	6
Copper Ridge	28-Aug-07	3	10:09	1671	611329	5417072	NA	NA	NA	NA	NA	NA	NA
Copper Ridge	28-Aug-07	4	11:05	1661	611330	5417326	NA	NA	NA	NA	NA	NA	NA
Copper Lake	28-Aug-07	1	8:33	1792	613376	5419024	NA	NA	NA	NA	NA	NA	NA
Copper Lake	28-Aug-07	2	9:20	1634	613634	5419294	NA	NA	NA	NA	NA	NA	NA
Copper Lake	28-Aug-07	3	10:09	1591	613754	5420170	NA	NA	NA	NA	NA	NA	N A
Copper Lake	28-Aug-07	4	10:55	1597	613946	5420531	NA	NA	NA	NA	NA	NA	NA
Copper Lake	28-Aug-07	5	11:37	1707	614215	5421056	NA	NA	NA	NA	NA	NA	NA
Copper Lake	28-Aug-07	6	12:20	1667	614787	5421259	NA	NA	NA	NA	NA	NA	NA
Copper Lake	28-Aug-07	7	13:06	1704	615379	5421956	NA	NA	NA	NA	NA	NA	NA
Whatcom Pass	30-Aug-07	1	7:22	1551	619709	5414895	NA	NA	NA	NA	NA	NA	NA
Whatcom Pass	30-Aug-07	2	8:05	1536	619543	5414764	NA	NA	NA	NA	NA	NA	NA
Whatcom Pass	30-Aug-07	3	9:07	1390	619028	5414674	NA	NA	NA	NA	NA	NA	NA
Goodie Ridge	5-Sep-07	1	7:10	1984	655916	5369014	NA	NA	NA	NA	NA	NA	NA
Goodie Ridge	5-Sep-07	2	8:27	1829	656109	5368826	NA	NA	NA	NA	NA	NA	NA
Goodie Ridge	5-Sep-07	3	9:25	1692	655962	5368345	NA	NA	NA	NA	NA	NA	NA
McGregor Mt.	5-Sep-07	1	7:30	2195	662550	5363800	NA	NA	NA	NA	NA	NA	NA
McGregor Mt.	5-Sep-07	2	8:30	2073	662500	5363500	838	148	112	A	unk	W	6
McGregor Mt.	5-Sep-07	2	8:30	2073	662500	5363500	848	210	226	A	unk	W	6
McGregor Mt.	5-Sep-07	3	9:10	2012	662150	5363350	910	75	242	V	A	W	6
McGregor Mt.	5-Sep-07	3	9:10	2012	662150	5363350	910	75	242	V	A	W	6
McGregor Mt.	5-Sep-07	3	9:10	2012	662150	5363350	912	20	240	V	A	W	6
McGregor Mt.	5-Sep-07	3	9:10	2012	662150	5363350	920	75	242	V	J	W	6
McGregor Mt.	5-Sep-07	3	9:10	2012	662150	5363350	922	75	242	V	J	W	6
Whatcom Pass East	26-Jun-08	1	8:22	1224	620592	5414617	NA	NA	NA	NA	NA	NA	NA

[1]**Vegetation Types:** 1). heather; 2). huckleberry; 3). sedge/grass; 4). forb (dominant); 5.) moss; 6). talus/boulder; 7). Mtn. ash (shrub); 8). Mt. hemlock (islands); 9.) subalpine fir; 10.) larch; 11.) whitebark pine
Note 1: NA means “not applicable” when no marmots were detected at the point count station.
Note 2: 2x after site name indicates site was surveyed twice with the greater of the two count numbers recorded here.

Appendix E. Data collected during 2007-2008 marmot surveys in NOCA (continued).

Site Name	Date	Point Count	Point Start Time	Elev Point (m)	UTM_x Point NAD 83)	UTM_y Point (NAD 83)	Detection Time	Distance to Marmot (m)	Azimuth	Audio/Visual	Age	Aspect	[1]Dominant Veg Type
Whatcom Pass East	26-Jun-08	2	9:01	1362	620482	5414723	NA	NA	NA	NA	NA	NA	NA
Whatcom Pass East	26-Jun-08	3	10:06	1483	620376	5414873	NA	NA	NA	NA	NA	NA	NA
Whatcom Pass East	26-Jun-08	4	10:54	1586	620079	5414894	NA	NA	NA	NA	NA	NA	NA
Fisher Ck.	9-Jul-08	1	16:47	1569	658094	5381623	NA	NA	NA	NA	NA	NA	4
Fisher Ck.	9-Jul-08	2	17:35	1529	657626	5381675	NA	NA	NA	NA	NA	NA	NA
Fisher Ck.	9-Jul-08	3	18:20	1520	657383	5381641	NA	NA	NA	NA	NA	NA	NA
Lone Mountain	22-Jul-08	1	10:24	1935	678665	5358165	NA	NA	NA	NA	NA	NA	NA
Lone Mountain	22-Jul-08	2	11:01	1951	678673	5358436	NA	NA	NA	NA	NA	NA	NA
Lone Mountain	22-Jul-08	3	11:35	2025	678421	5358371	NA	NA	NA	NA	NA	NA	NA
Lake Juanita	22-Jul-08	1	8:33	1993	677856	5354351	NA	NA	NA	NA	NA	NA	NA
Lake Juanita	22-Jul-08	2	9:33	2091	678002	5354364	9:40	120	130	V	A	E	6
Lake Juanita	22-Jul-08	2	9:33	2092	678002	5354364	9:54	135	82	V	A	SE	4
Lake Juanita	22-Jul-08	3	10:44	2076	678348	5354537	10:54	92	190	V	A	S	4
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:36	15	220	V	A	S	4
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:38	20	10	V	A	S	6
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:39	20	10	V	Y	S	6
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:40	190	42	V	A	S	6
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:50	120	282	A	U	S	10
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:50	180	310	A	U	S	10
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:50	190	260	A	U	S	10
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:54	65	130	V	A	S	4
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:55	130	160	V	A	S	4
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:56	95	112	V	Y	S	6
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:56	95	112	V	Y	S	6
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:57	120	156	V	A	S	4
Lake Juanita	22-Jul-08	4	11:35	2027	678659	5354812	11:57	110	156	V	A	S	4
Thornton Lakes	4-Aug-08	1	11:30	1500	623153	5393342	NA	NA	NA	NA	NA	NA	6
Thornton Lakes	4-Aug-08	2	12:20	1503	622850	5393558	NA	NA	NA	NA	NA	NA	2
Stilleto Peak	12-Aug-08	1	16:00	1655	670465	5372073	NA	NA	NA	NA	NA	NA	4
Stilleto Peak	12-Aug-08	2	16:51	1777	670750	5372049	NA	NA	NA	NA	NA	NA	4
Stilleto Peak	12-Aug-08	3	17:41	1884	671112	5372282	NA	NA	NA	NA	NA	NA	4
Stilleto Peak	12-Aug-08	4	18:28	1987	671179	5372672	NA	NA	NA	NA	NA	NA	4
Stilleto Peak	13-Aug-08	5	10:10	2115	671537	5372709	10:18	138	192	V	A	S	6
Stilleto Peak	13-Aug-08	5	10:10	2115	671537	5372709	10:25	128	180	V	A	S	6
Stilleto Peak	13-Aug-08	5	10:10	2115	671537	5372709	10:28	212	198	V	A	S	6
Stilleto Peak	13-Aug-08	5	10:10	2115	671537	5372709	10:30	217	160	V	A	S	6
Stilleto Peak	13-Aug-08	5	10:10	2115	671537	5372709	10:30	217	160	V	A	S	6
Fisher Ck. Basin 2x	26-Aug-08	1	7:32	1591	658486	5381595	7:52	192	106	V	A	N	6
Fisher Ck. Basin 2x	26-Aug-08	1	7:32	1591	658486	5381595	7:52	84	106	V	J	N	6
Fisher Ck. Basin 2x	26-Aug-08	2	8:30	1597	658938	5381250	8:31	147	224	V	A	N	6
Fisher Ck. Basin 2x	26-Aug-08	2	8:30	1597	658938	5381250	8:32	238	152	V	A	N	6

[1]**Vegetation Types:** 1). heather; 2). huckleberry; 3). sedge/grass; 4). forb (dominant); 5.) moss; 6). talus/boulder; 7). Mtn. ash (shrub); 8). Mt. hemlock (islands); 9.) subalpine fir; 10.) larch; 11.) whitebark pine
Note 1: NA means "not applicable" when no marmots were detected at the point count station.
Note 2: 2x after site name indicates site was surveyed twice with the greater of the two count numbers recorded here.

Appendix E. Data collected during 2007-2008 marmot surveys in NOCA (continued).

Site Name	Date	Point Count	Point Start Time	Elev Point (m)	UTM_x Point NAD 83)	UTM_y Point (NAD 83)	Detection Time	Distance to Marmot (m)	Azimuth	Audio/Visual	Age	Aspect	[1]Dominant Veg Type
Fisher Ck. Basin 2x	26-Aug-08	2	8:30	1597	658938	5381250	8:46	147	224	V	J	N	6
Fisher Ck. Basin 2x	26-Aug-08	2	8:30	1597	658938	5381250	8:49	147	224	V	A	N	6
Fisher Ck. Basin 2x	26-Aug-08	2	8:30	1597	658938	5381250	8:50	245	170	V	A	N	4
Fisher Ck. Basin 2x	26-Aug-08	3	9:40	1603	659255	5381005	9:42	93	250	V	A	N	6
Fisher Ck. Basin 2x	26-Aug-08	3	9:40	1603	659255	5381005	9:42	108	258	V	J	N	6
Fisher Ck. Basin 2x	26-Aug-08	3	9:40	1603	659255	5381005	9:45	33	230	V	J	N	6
Fisher Ck. Basin 2x	26-Aug-08	3	9:40	1603	659255	5381005	10:02	63	142	V	Y	N	6
Fisher Ck. Basin 2x	26-Aug-08	3	9:40	1603	659255	5381005	10:04	408	38	V	A	S	4
Fisher Ck. Basin 2x	26-Aug-08	3	9:40	1603	659255	5381005	10:04	418	38	V	A	S	4
Fisher Ck. Basin 2x	26-Aug-08	3	9:40	1603	659255	5381005	10:05	36	22	V	A	S	4
Fisher Ck. Basin 2x	26-Aug-08	3	9:40	1603	659255	5381005	10:06	25	230	V	Y	N	6
Fisher Ck. Basin 2x	26-Aug-08	4	10:55	1618	659417	5380641	10:56	18	280	V	Y	N	6
Fisher Ck. Basin 2x	26-Aug-08	4	10:55	1618	659417	5380641	10:56	28	272	V	J	N	6
Fisher Ck. Basin 2x	26-Aug-08	4	10:55	1618	659417	5380641	10:57	52	320	V	J	N	6
Fisher Ck. Basin 2x	26-Aug-08	4	10:55	1618	659417	5380641	10:57	52	320	V	J	N	6
Fisher Ck. Basin 2x	26-Aug-08	4	10:55	1618	659417	5380641	10:57	56	320	V	A	N	6
Fisher Ck. Basin 2x	26-Aug-08	4	10:55	1618	659417	5380641	10:58	48	62	V	A	S	4
Fisher Ck. Basin 2x	26-Aug-08	4	10:55	1618	659417	5380641	10:58	48	62	V	A	S	4
Fisher Ck. Basin 2x	26-Aug-08	5	11:40	1673	659669	5380344	11:52	93	62	V	A	S	4
Fisher Ck. Basin 2x	26-Aug-08	5	11:40	1673	659669	5380344	11:53	47	204	V	A	N	6
Fisher Ck. Basin 2x	26-Aug-08	5	11:40	1673	659669	5380344	11:53	272	128	A	Unk	N	6
North Fork Bridge Ck. 2x	3 Sept. 08	1	8:42	1158	655800	5374190	8:43	88	60	A	Unk	SW	6
North Fork Bridge Ck. 2x	3 Sept. 08	1	8:42	1158	655800	5374190	8:55	75	34	V	A	SW	6
North Fork Bridge Ck. 2x	3 Sept. 08	1	8:42	1158	655800	5374190	9:05	66	2	V	Y	S	6
North Fork Bridge Ck. 2x	3 Sept. 08	1	8:42	1158	655800	5374190	9:05	36	360	V	A	S	4
North Fork Bridge Ck. 2x	3 Sept. 08	2	10:30	1219	654794	5374471	NA	NA	NA	NA	NA	NA	NA
North Fork Bridge Ck. 2x	3 Sept. 08	3	11:21	1257	653301	5374973	NA	NA	NA	NA	NA	NA	NA

[1]**Vegetation Types:** 1). heather; 2). huckleberry; 3). sedge/grass; 4). forb (dominant); 5). moss; 6). talus/boulder; 7). Mtn. ash (shrub); 8). Mt. hemlock (islands); 9.) subalpine fir; 10.) larch; 11.) whitebark pine
Note 1: NA means "not applicable" when no marmots were detected at the point count station.
Note 2: 2x after site name indicates site was surveyed twice with the greater of the two count numbers recorded here.

Appendix F. Area surveyed (km^2) and density (marmots/km^2) for each survey site during 2007-2008 marmot surveys in North Cascades National Park Complex.

Origination Site Name	Date	Avg. Point Count Elevation (m)	No. Marmots Detected	Area Surveyed (km^2)	Density (marmots per km^2)
Monogram Lake	26-Jun-07	1661	11	1.06	10.36
Sourdough Lookout	10-Jul-07	1647	0	1.17	0.00
Sourdough Mtn	10-Jul-07	1657	0	0.86	0.00
Jack Mtn 2	17-Jul-07	1980	16	1.69	9.45
Jack Mtn 1	18-Jul-07	1759	0	1.49	0.00
Desolation Peak	24-Jul-07	1736	12	1.26	9.56
South Pass	31-Jul-07	1881	19	2.32	8.18
Rainbow Creek	1-Aug-07	1643	9	1.48	6.10
Rainbow Ridge	1-Aug-07	1529	0	1.91	0.00
Rainbow Lake	2-Aug-07	1762	11	1.53	7.21
Purple Pass	9-Aug-07	2070	24	3.39	7.09
Twisp Pass	9-Aug-07	1962	7	2.04	3.43
Horseshoe Basin	14-Aug-07	1328	0	1.06	0.00
Pelton Basin	14-Aug-07	1403	15	0.85	17.62
Sahale Arm	15-Aug-07	1827	19	2.11	8.99
Park Creek Pass	21-Aug-07	1440	9	1.10	8.18
Park Creek Pass South	22-Aug-07	1708	22	1.19	18.49
Copper Lake	28-Aug-07	1670	0	3.39	0.00
Copper Lookout	28-Aug-07	1792	9	1.85	4.85
Copper Ridge	28-Aug-07	1668	3	1.69	1.77
Whatcom Pass	30-Aug-07	1493	0	1.20	0.00
Goode Ridge	5-Sep-07	1835	0	1.23	0.00
McGregor Mtn	5-Sep-07	2093	7	1.17	5.98
Whatcom Pass East	26-Jun-08	1414	0	1.13	0.00
Fisher Creek	9-Jul-08	1539	0	1.19	0.00
Lake Juanita	22-Jul-08	2047	16	1.39	11.50
Lone Mountain	22-Jul-08	1970	0	0.99	0.00
Thornton Lakes	4-Aug-08	1501	0	0.91	0.00
Stilleto Peak	13-Aug-08	1884	5	1.82	2.75
Fisher Creek Basin	26-Aug-08	1617	25	2.04	12.23
North Fork Bridge Creek	3 Sept. 08	1211	4	1.78	2.25

Appendix G. Other species detected during 2007-2008 marmot surveys in North Cascades National Park Complex.

Species Common Name	Origination Site Name Where Observation Occurred	Date	No. of individuals	Point Count No.	UTM at point count easting (NAD 83)	UTM at point count northing (NAD 83)	Point Elevation (m)
Black bear	Jack Mt. 2	17-Jul-07	1	4	648333	5401290	2030
Black bear	Pelton Basin	14-Aug-07	1	3	644262	5369457	1381
Black bear	Monogram Lake	10-Sep-08	3	1	626023	5379706	1634
Black bear	Fisher Ck. Basin	26-Aug-08	1	5	659669	5380344	1673
Black bear	North Fork Bridge Ck.	3-Sep-08	1	3	653012	5374973	1257
Black bear	Monogram Lake	26-Jun-07	1	3	625851	5379798	1698
Clark's nutcracker	Goodie Ridge	5-Sep-07	11	2	656109	5368826	1829
Colimbia ground squirrel	Jack Mt. 1	18-Jul-07	4	3	648042	5400375	1750
Colimbia ground squirrel	Jack Mt. 1	18-Jul-07	3	4	647943	5400228	1686
Colimbia ground squirrel	Desolation Pk.	24-Jul-07	6	3	645388	5419182	1545
Colimbia ground squirrel	South Pass	31-Jul-07	1	1	673177	5366260	1856
Colimbia ground squirrel	Twisp Pass	9-Aug-07	1	3	673728	5371787	1945
Colimbia ground squirrel	Twisp Pass	9-Aug-07	1	4	674334	5371440	1905
Cooper's hawk	South Pass	31-Jul-07	1	3	673467	5366044	1939
Coyote	Stilleto Pk.	13-Aug-09	4	5	671537	5372709	2115
Coyote	Purple Pass	18-Aug-08	4	4	680387	5353744	2033
Deer	Monogram Lake	26-Jun-07	1	3	625851	5379798	1698
Deer	Jack Mt. 1	18-Jul-07	2	1	648316	5400322	1821
Golden eagle	Copper Ridge	28-Aug-07	1	1	610209	5416965	1695
Golden eagle	Fisher Ck. Basin	26-Aug-08	1	3	659255	5381005	1603
Golden mantled ground squirrel	Jack Mt. 2	17-Jul-07	1	2	648615	5400764	2006
Golden mantled ground squirrel	Jack Mt. 2	17-Jul-07	1	3	648507	5400982	2051
Golden mantled ground squirrel	Desolation Pk.	24-Jul-07	6	3	645388	5419182	1545
Golden mantled ground squirrel	Desolation Pk.	24-Jul-07	4	4	645565	5418822	1725
Golden mantled ground squirrel	South Pass	31-Jul-07	6	1	673177	5366260	1856
Golden mantled ground squirrel	South Pass	31-Jul-07	2	3	673467	5366044	1939
Golden mantled ground squirrel	South Pass	31-Jul-07	1	4	673611	5365643	1908
Golden mantled ground squirrel	South Pass	31-Jul-07	1	5	673776	5365148	1859
Golden mantled ground squirrel	Rainbow Ck.	1-Aug-07	1	2	668560	5362650	1631
Golden mantled ground squirrel	Rainbow Ridge	1-Aug-07	1	3	671287	5364214	1527
Golden mantled ground squirrel	Twisp Pass	9-Aug-07	1	3	673728	5371787	1945
Golden mantled ground squirrel	Twisp Pass	9-Aug-07	1	4	674334	5371440	1905
Golden mantled ground squirrel	Twisp Pass	9-Aug-07	1	5	674499	5371238	1887
Golden mantled ground squirrel	Goodie Ridge	5-Sep-07	2	2	656109	5368826	1829
Golden mantled ground squirrel	Purple Pass	9-Aug-07	1	3	680814	5353568	2079
Golden mantled ground squirrel	Purple Pass	9-Aug-07	2	9	678805	5354793	2033
Golden mantled ground squirrel	Park Ck. Pass So.	22-Aug-07	2	3	651078	5372852	1689
Golden mantled ground squirrel	Copper Lookout	28-Aug-07	1	1	613153	5418861	1829
Golden mantled ground squirrel	Stilleto Pk.	12-Aug-08	1	1	670465	5372073	1655
Golden mantled ground squirrel	Stilleto Pk.	12-Aug-08	1	3	671112	5372282	1884

Appendix G. Other species detected during 2007-2008 marmot surveys in North Cascades National Park Complex (continued).

Species Common Name	Origination Site Name Where Observation Occurred	Date	No. of individuals	Point Count No.	UTM at point count easting (NAD 83)	UTM at point count northing (NAD 83)	Point Elevation (m)
Golden mantled ground squirrel	Twisp Pass	14-Aug-08	2	3	673728	5371787	1945
Mountain goat	Horseshoe Basin	14-Aug-07	1	3	646156	5371024	1268
Mountain goat	Twisp Pass	9-Aug-07	1	1	673142	5372346	2065
Northern harrier hawk	Monogram Lake	10-Sep-08	2	1	626023	5379706	1634
Peregrine falcon	Monogram Lake	10-Sep-08	1	1	626023	5379706	1634
Pika	Desolation Peak	24-Jul-07	1	1	645302	5419553	1823
Pika	Rainbow Ridge	1-Aug-07	1	1	672195	5364858	1529
Pika	Rainbow Ridge	1-Aug-07	1	2	671703	5364650	1575
Pika	Purple Pass	9-Aug-07	1	5	680220	5354161	2036
Pika	Purple Pass	9-Aug-07	1	6	679731	5354365	2045
Pika	Horseshoe Basin	14-Aug-07	1	1	646073	5371392	1353
Pika	Horseshoe Basin	14-Aug-07	1	2	645922	5371020	1362
Pika	Horseshoe Basin	14-Aug-07	1	3	646156	5371024	1268
Pika	Sahale Arm	15-Aug-07	1	1	643524	5370119	1609
Pika	Sahale Arm	15-Aug-07	1	2	647773	5370346	1762
Pika	Sahale Arm	15-Aug-07	1	3	643739	5370758	1838
Pika	Park Creek Pass	21-Aug-07	2	2	649789	5374486	1506
Pika	Park Creek Pass So.	22-Aug-07	1	1	650609	5373389	1737
Pika	Copper Lookout	28-Aug-07	1	1	613153	5418861	1829
Pika	Copper Lake	28-Aug-07	1	1	613376	5419024	1792
Pika	Copper Lake	28-Aug-07	1	2	613634	5419294	1634
Pika	Copper Lake	28-Aug-07	1	4	613946	5420531	1597
Pika	Copper Lake	28-Aug-07	1	7	615379	5421956	1704
Pika	Whatcom Pass	30-Aug-07	1	1	619709	5414895	1551
Pika	Whatcom Pass	30-Aug-07	1	2	619543	5414764	1536
Pika	Whatcom Pass	30-Aug-07	1	3	619028	5414674	1390
Pika	McGregor Mt.	5-Sep-07	1	1	662550	5363800	2195
Pika	Monogram Lake	8-Jul-08	1	1	626023	5379706	1786
Pika	Purple Pass	23-Jul-08	1	1	681380	5353502	2198
Pika	Purple Pass	23-Jul-08	1	2	681183	5353196	2100
Pika	Stilleto Peak	12-Aug-08	1	1	670465	5372073	1655
Pika	Stilleto Peak	12-Aug-08	1	2	670750	5372049	1777
Pika	Stilleto Peak	12-Aug-08	1	4	671179	5372672	1987
Pika	Twisp Pass	14-Aug-08	1	1	673142	5372346	2065
Pika	Twisp Pass	14-Aug-08	1	2	673523	5372098	2009
Pika	Fisher Ck. Basin	26-Aug-08	1	1	658486	5381595	1591
Pika	Fisher Ck. Basin	26-Aug-08	1	2	658938	5381250	1597
Pika	Fisher Ck. Basin	26-Aug-08	1	3	659255	5381005	1603
Pika	Fisher Ck. Basin	26-Aug-08	1	5	659669	5380344	1673
Pika	North Fork Bridge Ck.	3 Sept. 08	1	1	655800	5374190	1158
Pika	Thornton Lakes	9-Sep-08	1	1	623153	5393342	1500

Appendix G. Other species detected during 2007-2008 marmot surveys in North Cascades National Park Complex (continued).

Species Common Name	Origination Site Name Where Observation Occurred	Date	No. of individuals	Point Count No.	UTM at point count easting (NAD 83)	UTM at point count northing (NAD 83)	Point Elevation (m)
Sharp-shinned hawk	North Fork Bridge Ck.	3-Sep-08	1	2	654794	5374471	1219
Spruce grouse	Sahale Arm	15-Aug-07	1	4	643634	5371163	1939
Townsend's chipmunk	Jack Mt. 2	17-Jul-07	1	2	648615	5400764	2006
Townsend's chipmunk	Desolation Pk.	24-Jul-07	2	4	645565	5418822	1725
Townsend's chipmunk	Rainbow Ck.	1-Aug-07	3	1	668654	5363447	1576
Townsend's chipmunk	Copper Lake	28-Aug-07	1	7	615379	5421946	1704
Townsend's chipmunk	Fisher Ck. Basin	10-Jul-08	1	1	658486	5381545	1593

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